United States Department of Agriculture

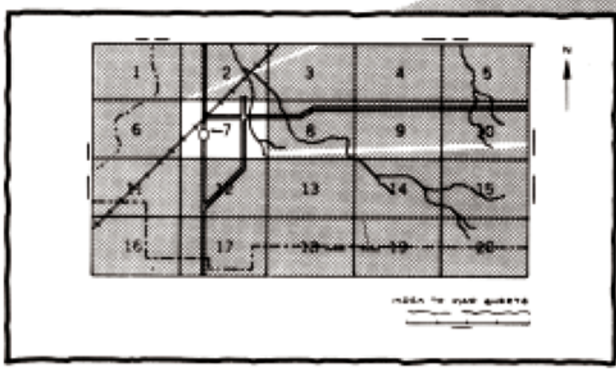
Soil Conservation Service

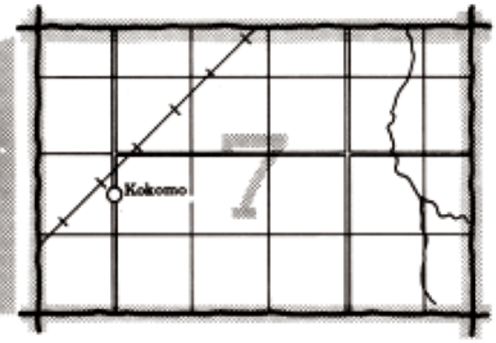
In Cooperation with Iowa Agriculture and Home Economics Experiment Station and the Cooperative Extension Service Iowa State University and the Department of Soil Conservation State of Iowa

Soil Survey of Story County, Iowa

HOW TO USE

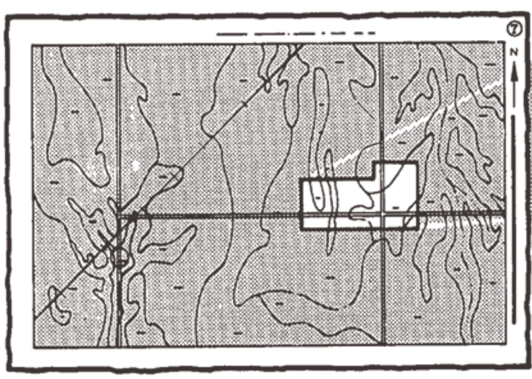
1. Locate your area of interest on the "Index to Map Sheets"

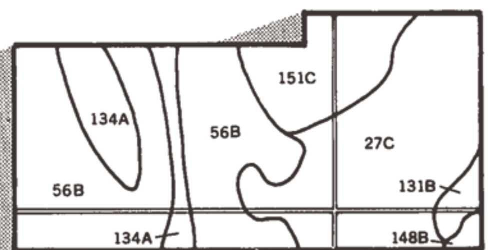




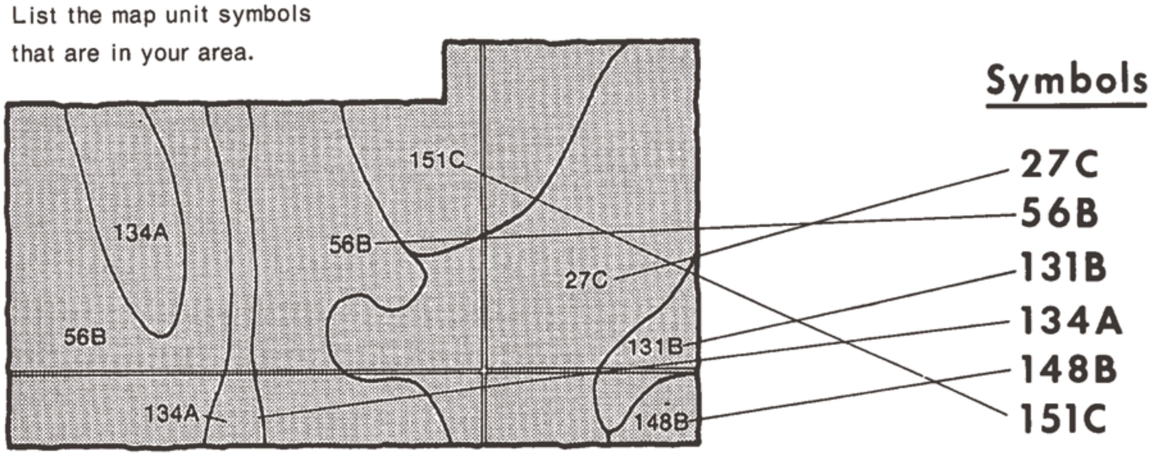
2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.



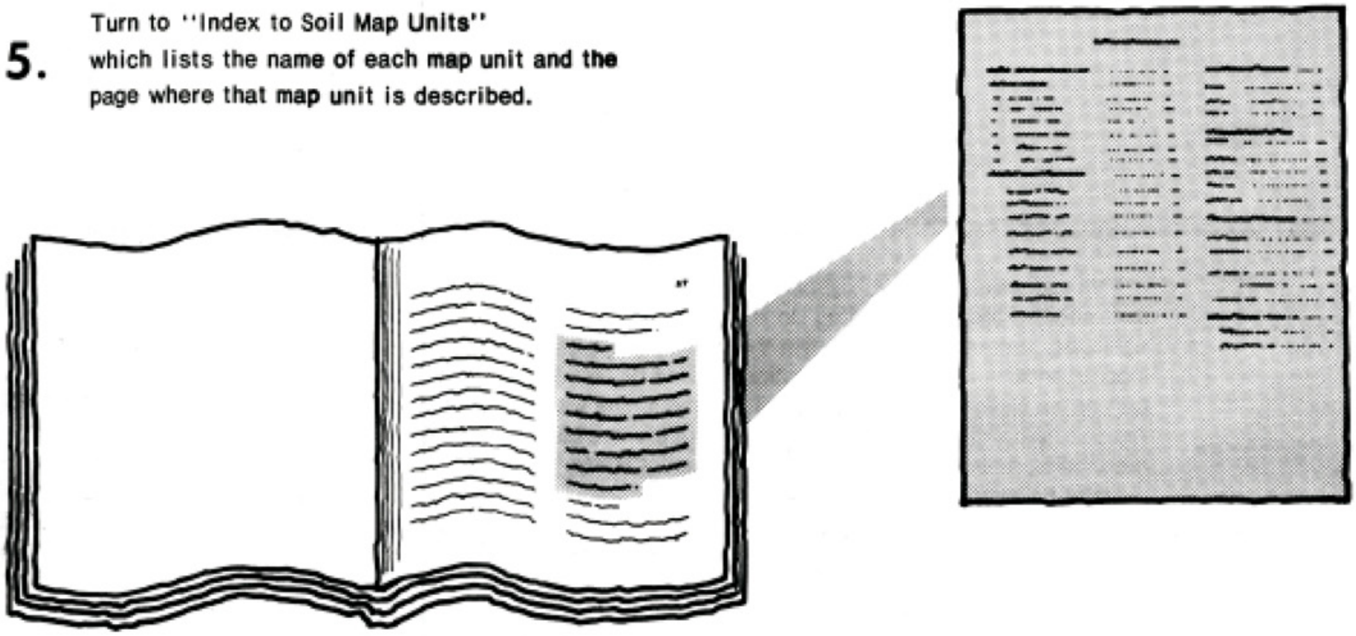


4. List the map unit symbols that are in your area.

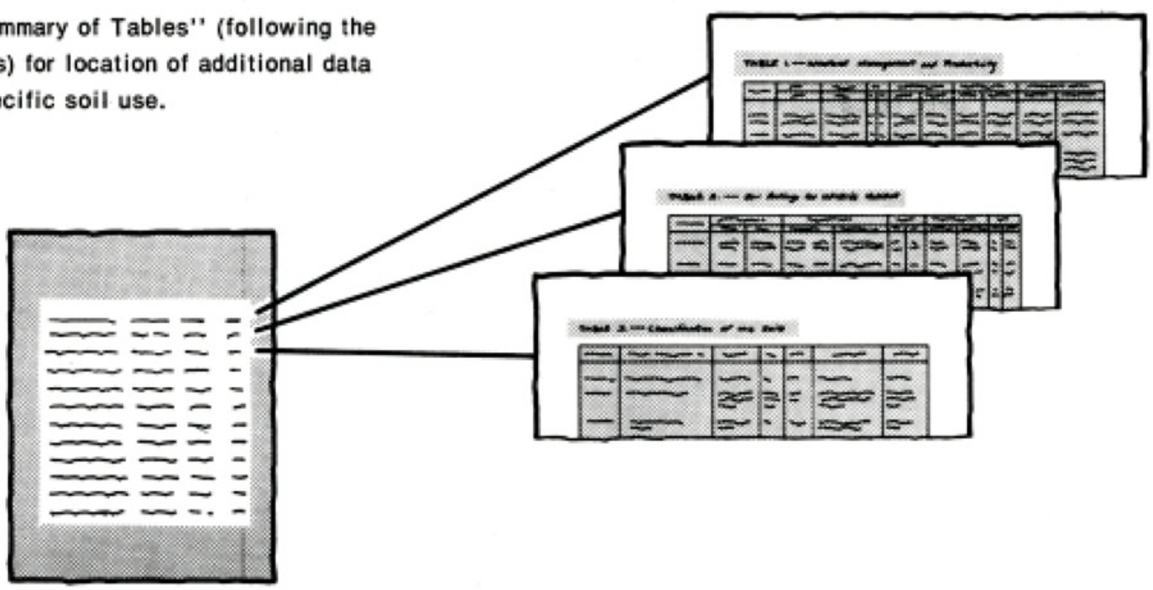


THIS SOIL SURVEY

5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

This survey was made cooperatively by the Soil Conservation Service; the Iowa Agriculture and Home Economics Experiment Station and the Cooperative Extension Service, Iowa State University; and The Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Story County Soil Conservation District. Funds appropriated by Story County and the city of Ames were used to defray part of the cost of the survey.

Major fieldwork for this soil survey was completed in 1976-1980. Soil names and descriptions were approved in 1981. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1980.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Cover: Soybeans on Nicollet loam, 1 to 3 percent slopes. In most areas, this soil is intensively cropped.

Contents

Soil Series

Issued May 1984

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Summary of Tables

Preface

This soil survey contains information that can be used in land-planning programs in Story County, Iowa. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

STORY COUNTY SOIL SURVEY REPORT SUPPLEMENT*

This supplement includes supplementary and updated information compiled for the for the Story County soil survey report dated May, 1984.

The supplementary portion contains corn suitability ratings (CSRs) which are not found in the report. Additional supplementary information includes an explanation of subsoil fertility terms, and a definition of erosion classes. The updated portion provides yield estimates for commonly grown crops.

Corn Suitability Ratings provide a relative ranking of all soils mapped in the State of Iowa based on their potential to be utilized for intensive row crop production. The CSR is an index that can be used to rate one soil s potential yield production against another over a period of time. The CSR index considers average weather conditions as well as frequency of use of the soil for row crop production. Ratings range from 100 for soils that have no physical limitations, occur on minimal slopes, and can be continuously row cropped to as low as 5 for soils with severe limitations for row crops. The highest CSR value in Story County is 94. The ratings listed in this supplement assume a) adequate management, b) natural weather conditions (no irrigation), c) artificial drainage where required, d) soils lower on the landscape are not affected by frequent floods, and e) no land leveling or terracing. The CSR for a given field can be modified by the occurrence of sandy spots, rock outcropping, field boundaries, and so forth. Even though predicted average yields (Table 5, pp. 104-107) will range with time, the CSRs are expected to remain relatively constant in relation to one another. The CSR can be useful

++++++++++++++++++++++++++++++ *Prepared by Gerald A. Miller, Extension Agronomist and Thomas E.Fenton, Research Agronomist, Iowa State University; and Thomas A. DeWitt, Soil Scientist, Soils Conservation Service. CSR values were taken from information provided the Story County Assessor by the Iowa Cooperative Soil Susrvey Staff. Prepared June 1984.*

to farmers, land buyers, and assessors and others as an aid in determining suitable land use and land value. The CSRs assigned for individual tracts of land by the Story County Assessor may differ from those listed in the accompanying table. These differences are due to adjustments for waterways, land use for woodland and forest reserves, and combination of some soil mapping units during correlation of the final report.

Subsoil nutrient levels. Inherent subsoil fertility levels in terms of potential plant available phosphorus and potassium are described for each soil map unit in Story County (pp. 15-45). The qualitative ratings of available phosphorus and potassium assigned to each soil mapping unit are for the following depths in the soil profile: Phosphorus 24 to 36 inches and potassium, 6 to 12 inches.

Soil test of the plow layer are used to determine the most profitable rates of fertilizers for various crops. Nutrient levels in the subsurface layers do influence crop yields, particularly in drier seasons when the nutrients in the dry tilled layer become temporarily unavailable to plants. The availability of nutrients in the tilled layer and subsoil influences the relative uptake from the two zones in the soil profile. Fertilizer recommendations based on soil tests of the tilled layer may be adjusted by the average nutrient levels in the subsoil of each soil series. The fertilizer recommendations made by the Iowa State University Soil Testing Laboratory are adjusted for subsoil nutrient levels. The potential plant available subsoil phosphorus and potassium classes are described as follows:

Subsoil phosphorus (P). The base for the subsoil phosphorus level in soil test recommendations from the Iowa State University Soil Testing Laboratory are:

Soil Test Class	Soil Test Value, lbs/A
Very Low (VL)	Less than 15
Low (L)	15 to 25
Medium (M)	26 to 45
High (H)	Greater than 45

Subsoil potassium (K). The base for subsoil potassium level in soil test recommendations from the Iowa State University Soil Testing Laboratory are:

Soil Test Class	Soil Test Value, lbs/A
Very Low minus (VL-)	Less than 40
Very Low plus (VL+)	40 to 79
Low (L)	80 to 125
Medium (M)	126 to 200
High (H)	201 to 300
Very High (VH)	Greater than 300

Soil Mapping Unit Erosion classes. The soil mapping unit name includes the soil type name, the slope gradient in percent, and the erosion class. For example, 138C2 is the soil mapping unit symbol for Clarion loam, 5 to 9 percent slopes, moderately eroded. The soil type, Clarion loam, is identified by the number 138. The slope gradient, 5 to 9 percent slopes, is identified by the letter C, and the erosion class, moderately eroded, is identified by the number 2. The erosion class of a soil mapping unit is classified by soil scientists based on the thickness of the A horizon and/or the amount of mixing of subsoil material in the tilled layer of cultivated soils.

A description of the erosion classes used in the Story County Soil Survey Report is outlined in the following table.

Erosion Symbol	Erosion Class Name	Description
+	Overwash	Recent deposition. 8 to 18 inches of lighter-colored material deposited on an existing A horizon.
(no symbol indicated. Blank)	None or slightly eroded	The tilled layer consists of A horizon material. Soils on 0 to 1% 0 to 2%, and 1 to 3% slopes usually have a A horizon thickness of 10 inches or greater. Soil on 2 to 5% or steeper slopes usually have 7 to 12 inches of A horizon material. Little or no mixing of the subsoil material occurs in the tilled layer.
2	Moderately eroded	Dark colored A horizon material is 3 to 7 inches thick;. Some mixing of subsoil material is present in the tilled layer.
3	Severely eroded	Dark colored A horizon material is less than 3 inches thick. A major portion of the tilled layer consists of subsoil material.

Yield estimates. The yield estimates listed in this supplement are provided to update corn, soybeans, oats, and grass-legume hay yields listed on Table 5 (pp. 104-107) of the report. These updated yields are estimated for high level management and are normalized for a five-year average. The yields listed in Table 5 for smooth bromegrass, Kentucky bluegrass and bromegrass-alfalfa are satisfactory estimates.

High level management includes the adaption of best available technology for crop production to include agronomic, engineering, and economic practices. For example, best available technology for corn production includes tillage and engineering practices that maintain soil erosion rates at or below tolerance limits. Also, best available technology includes use of artificial drainage on those soils requiring the removal of excess water for optimum plant root growth and development and protection from periodic flooding for those soils adjacent to drainageways, streams, and rivers.

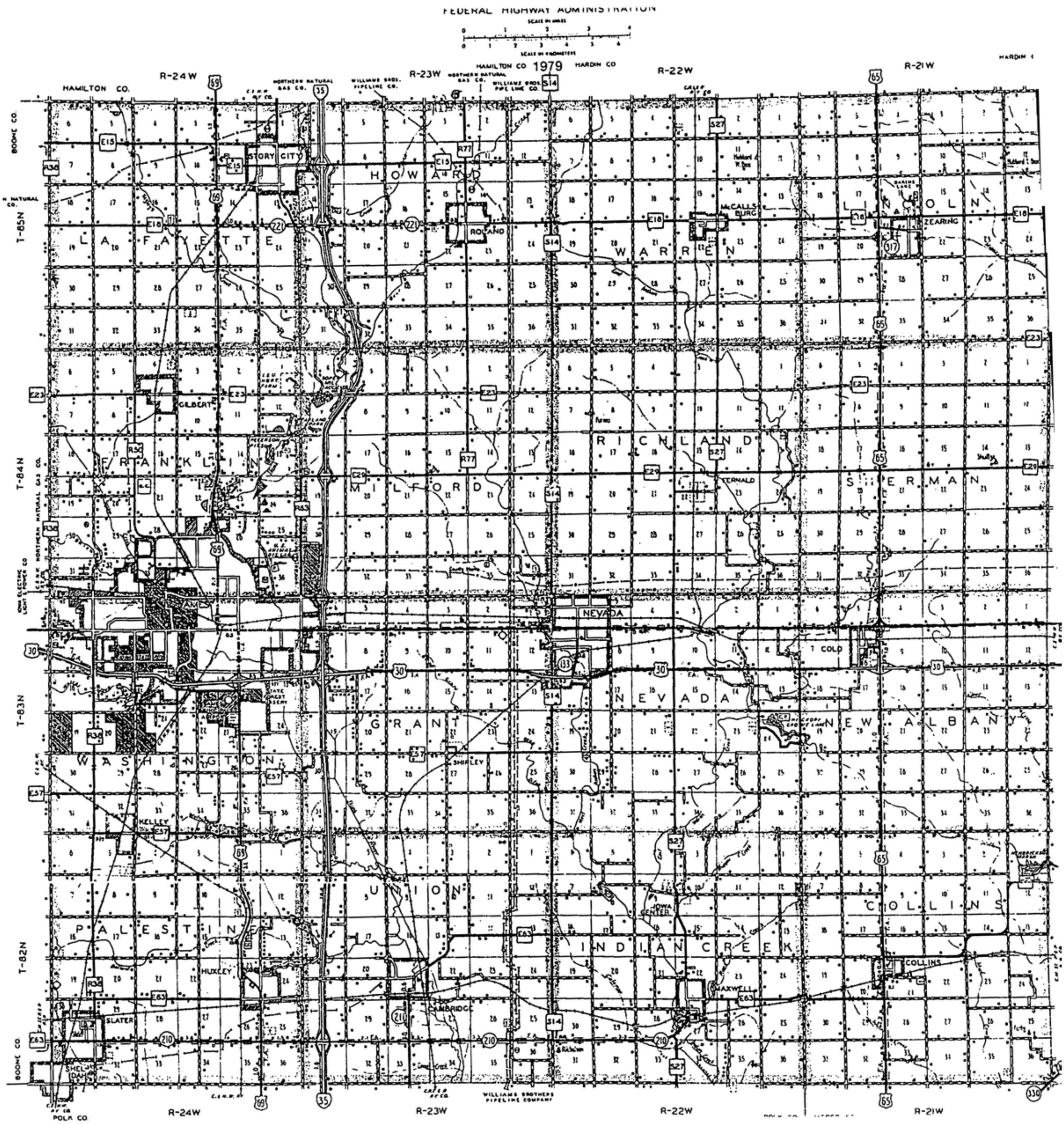
Other management practices may include cultivar selection, planting dates, optimum population, row-spacing, optimum fertilization and liming rates, weed and insect control, and timely and efficient harvest practices. All yield estimates are for dryland (non-irrigated) conditions.

Five-year average estimates are used to smooth the effects of weather variations on a year-to-year basis.

Yield estimates for soybeans, oats, and alfalfa-grass hay are calculated from a percentage of the estimated corn yields. Kind of parent material is considered in the calculation of soybean yield estimates. Natural soil drainage class is considered in the calculation of alfalfa-grass hay yield estimates. The alfalfa-grass hay yields assume 80 percent or more alfalfa in the stand with either orchardgrass or bromegrass.

Soil Map Symbol	Soil Mapping Unit Name	CSR	Land Capability Class	Corn Bu/Ac	Soybeans Bu/Ac	Oats Bu/Ac	Alfalfa Brome T/Ac	Kentucky Bluegrass T/Ac
6	Okoboji silty clay loam, 0 to 1% slopes	59	3W	117	37	82	3.5	2.9
27B	Terril loam, 2 to 5% slopes	86	2E	152	49	106	6.4	3.7
27C	Terril loam, 5 to 9% slopes	70	3E	147	47	103	6.2	3.6
34C	Estherville sandy loam, 2 to 9% slopes	14	4E	56	18	39	2.4	1.4
41B	Sparta loamy fine sand, 2 to 5% slopes	42	4S	86	28	60	3.6	2.1
41C	Sparta loamy fine sand, 5 to 9% slopes	26	4S	81	26	57	3.4	2
41D	Sparta loamy fine sand, 9 to 14% slopes	16	6S	NA	NA	50	3	1.8
52B	Bode clay loam, 2 to 5% slopes	84	2E	149	48	104	6.3	3.7
54	Zook silty clay loam, 0 to 2% slopes	73	2W	131	42	92	3.9	3.2
55	Nicollet loam, 1 to 3% slopes	94	1	163	52	114	6.5	4
62C3	Storden loam, 5 to 9% slopes, severely eroded	49	3E	120	38	84	5	3
62D	Storden loam, 9 to 14% slopes	44	3E	123	39	86	5.2	3
62D3	Storden loam, 9 to 14% slopes, severely eroded	39	4E	111	35	78	4.7	2.7
62E	Storden loam, 14 to 18% slopes	33	4E	106	34	74	4.4	2.6
62E3	Storden loam, 14 to 18% slopes, severely eroded	28	6E	NA	NA	NA	3.7	2.3
62F	Storden loam, 18 to 25% slopes	13	6E	NA	NA	NA	3.4	2.4
65F	Lindley loam, 18 to 25% slopes	10	7E	NA	NA	NA	2.5	1.8
90	Okoboji mucky silt loam, 0 to 1% slopes	62	3W	123	39	86	3.7	3
95	Harps loam, 1 to 3% slopes	66	2W	131	42	92	3.9	3.2
107	Webster clay loam, 0 to 2% slopes	89	2W	152	49	106	4.6	3.7
108	Wadena loam, 24 to 32" to sand & gravel, 0 to 2% slopes	57	2S	102	33	71	4.3	2.5
108B	Wadena loam, 24 to 32" to sand & gravel, 2 to 5% slopes	52	2E	99	32	69	4.2	2.4
135	Coland clay loam, 0 to 2% slopes	84	2W	143	46	100	4.3	3.5
136B	Ankeny fine sandy loam, 2 to 5% slopes	58	3E	100	32	70	4.2	2.5
138B	Clarion loam, 2 to 5% slopes	86	2E	152	49	106	6.4	3.7
138C	Clarion loam 5 to 9% slopes	70	3E	147	47	103	6.2	3.6
138C2	Clarion loam, 5 to 9% slopes, moderately eroded	68	3E	143	46	100	6	3.5
138D2	Clarion loam, 9 to 14% slopes, moderately eroded	58	3E	134	43	94	5.6	3.3
168B	Hayden loam, 2 to 5% slopes	75	2E	132	42	92	5.5	3.2
168C	Hayden loam, 5 to 9% slopes	60	3E	127	41	89	5.3	3.1
168E	Hayden loam, 9 to 18% slopes	43	4E	101	32	71	4.2	2.5
168F	Hayden loam, 18 to 25% slopes	18	6E	NA	NA	NA	NA	2.2
175	Dickinson fine sandy loam, 0 to 2% slopes	63	3S	118	38	83	5	2.9
175B	Dickinson fine sandy loam, 2 to 5% slopes	58	3E	115	37	81	4.8	2.8
175C	Dickinson fine sandy loam, 5 to 9% slopes	42	3E	110	35	77	4.6	2.7
201B	Coland-Terril complex, 1 to 5% slopes	40	2W	83	27	58	2.5	2
202	Cylinder loam, 24 to 32" to sand & gravel, 0 to 2% slopes	69	2S	123	39	86	4.9	3

Soil Map Symbol	Soil Mapping Unit Name	CSR	Land Capability Class	Corn Bu/Ac	Soybeans Bu/Ac	Oats Bu/Ac	Alfalfa Brome T/Ac	Kentucky Bluegrass T/Ac
203	Cylinder loam, 32 to 40" to sand & gravel, 0 to 2% slopes	82	1	144	47	100	5.8	3.5
221	Palms muck, 0 to 1% slopes	52	3W	120	38	84	3.6	3
236B	Lester loam, 2 to 5% slopes	81	2E	143	46	100	6	3.5
236C	Lester loam, 5 to 9 % slopes	65	3E	138	44	97	5.8	3.4
236C2	Lester loam, 5 to 9% slopes, moderately eroded	63	3E	134	43	94	5.6	3.3
236D	Lester loam, 9 to 14% slopes	54	3E	129	41	90	5.4	3.2
236D2	Lester loam, 9 to 14% slopes, moderately eroded	52	3E	125	40	88	5.3	3.1
236E	Lester loam, 14 to 18% slopes	44	4E	112	36	78	4.7	2.8
236F	Lester loam, 18 to 25% slopes	23	6E	NA	NA	NA	NA	2.5
253B	Farrar fine sandy loam, 2 to 5% slopes	64	2E	125	40	88	5.3	3.1
259	Biscay clay loam, 32 to 40% to sand&gravel, 0 to 2% slope	81	2W	138	44	97	4.2	3.4
274	Rolfe silt loam, 0 to 1% slopes	55	3W	109	35	76	3.3	2.7
284	Flagler sandy loam, 0 to 2% slopes	52	3S	90	29	63	3.8	2.2
284B	Flagler sandy loam, 2 to 5% slopes	47	3E	87	29	52	3.7	2.1
288	Ottosen clay loam, 1 to 3% slopes	90	1	157	50	110	6.3	3.9
356G	Hayden-Storden loams, 25 to 50% slopes	5	7E	NA	NA	NA	NA	2.1
386	Cordova clay loam, 0 to 2% slopes	84	2W	143	46	100	4.3	3.5
388	Kossuth silty clay loam, 0 to 2% slopes	83	2W	140	45	98	4.2	3.5
485	Spillville loam, 0 to 2% slopes	92	2W	156	50	109	6.2	3.8
506	Wacousta silty clay loam, 0 to 1% slopes	79	3W	130	42	91	3.9	3.2
507	Canisteo clay loam, 0 to 2% slopes	84	2W	146	47	102	4.4	3.6
536	Hanlon fine sandy loam, 0 to 2% slopes	73	2S	125	40	88	5.3	3.1
559	Talcot clay loam, 32 to 40" to sand & gravel, 0 to 2% slopes	75	2W	130	42	91	5.8	3.2
638C2	Clairon-Storden loams, 5 to 9% slopes, moderately eroded	61	3E	137	44	96	5.4	3.4
638D2	Clairon-Storden loams, 9 to 14% slopes, moderately eroded	51	3E	128	41	90	4.8	3.1
828B	Zenor sandy loam, 2 to 5% slopes	52	3E	93	30	65	3.9	2.3
828C2	Zenor sandy loam, 5 to 9% slopes, moderately eroded	35	3E	85	27	60	3.6	2.1
956	Harps-Okoboji complex, 0 to 2% slopes	60	3W	120	38	84	3.6	3
1178	Waukee Variant loam, 0 to 2% slopes	87	1	141	45	99	5.9	3.5
1314	Hanlon-Spillville complex, channeled, 0 to 2% slopes	25	5W	NA	NA	NA	NA	NA
1585	Spillville-Coland complex, channeled, 0 to 2% slopes	25	5W	NA	NA	NA	NA	NA
4000	Urban land	Not rated						
5010	Pits, gravel	Not rated						
5030	Pits, quarry	Not rated						
5040	Orthents, loamy	Not rated						
5050	Orthents, sandy	Not rated						
5060	Pits, clay	Not rated						



FEDERAL HIGHWAY ADMINISTRATION
SCALE IN MILES
SCALE IN KILOMETERS
HAMILTON CO
1979
HARDIN CO
HAMILTON CO.
R-24W
R-23W
R-22W
R-21W
NORTHERN NATURAL GAS CO.
WILLIAMS BROS. PIPELINE CO.
T-85N
T-84N
T-83N
T-82N
BOONE CO.
POLK CO.
STORY CITY
HOWARD
ROLAND
LAFAYETTE
WARREN
McCALLSBURG
LINCOLN
ZEARING
GILBERT
RICHLAND
FRANKLIN
MILFORD
FERNALD
SHERMAN
NEVADA
COLO
GRANT
NEW ALBANY
SHIRLEY
WASHINGTON
KELLEY
UNION
COLLINS
PALESTINE
IOWA CENTER
INDIAN CREEK
HUXLEY
MAXWELL
CAMBRIDGE
SLATER
SHELDAHL
WILLIAMS BROTHERS PIPELINE COMPANY

Soil Survey of Story County, Iowa

By Thomas A. DeWitt, Soil Conservation Service

Fieldwork by Thomas A. DeWitt, Robert C. Russell, James C. Sanner, Byron F. Chalstrom, and Michael J. Wiemann, Soil Conservation Service; and Harry R. James, Iowa State University

United States Department of Agriculture, Soil Conservation Service
In Cooperation with the Iowa Agriculture and Home Economics Experiment Station and the Cooperative Extension Service
Iowa State University and
The Department of Soil Conservation, State of Iowa

Story County is in the geographic center of Iowa (fig. 1). It is square in shape, measuring 24 miles from both north to south and east to west. The total area is 363,520 acres, or about 568 square miles. The present boundaries were established in 1846.

The entire county was originally prairie, with the exception of some areas of timber along the larger streams. Soils in the county formed in glacial till, alluvium, eolian, and organic parent materials. The topography is predominantly undulating. There are some nearly level areas, a few rolling to hilly sections, and numerous small shallow depressions. Most drainageways are not well developed.

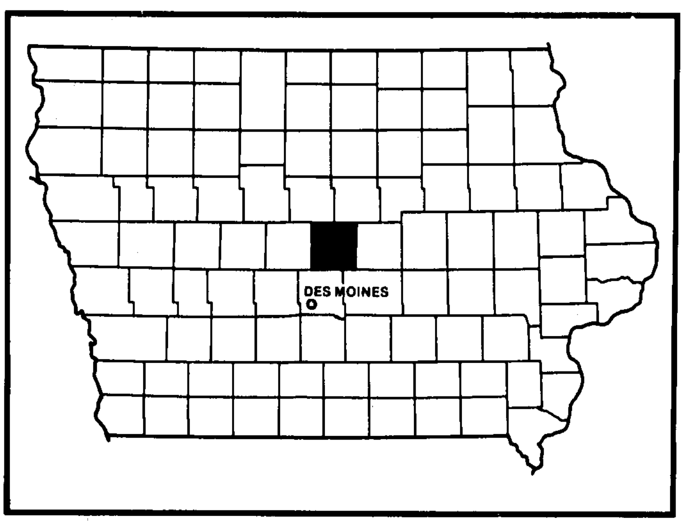


Figure 1.—Location of Story County in Iowa.

About 80 percent of the county is cultivated. Corn and soybeans are the major crops. Other important crops are small grains, hay, and rotation pasture.

The first soil survey of Story County was published in 1904 (*12*). A second soil survey of the county was published in 1941 (*13*). This survey updates these previous surveys and provides additional information and larger maps that show more detail.

General Nature of the Survey Area

This section presents general information about the county. It includes a brief discussion of the history, relief and drainage, farming, transportation, and climate of the county.

History

The first settlers in Story County came mainly from Indiana, New York, and Pennsylvania (*5*). Other early settlers included many Norwegians, Germans, and Danes. The first great population influx was in the early 1850's. State of Iowa figures give the population as 214 in 1852. This had increased to 4,051 in 1860.

Nevada became the county seat in 1853. The county was named for Joseph Story, an associate justice of the United States Supreme Court.

Railroad construction greatly accelerated the development of Story County. When the first railroad came to the county in 1864, several established towns moved to be on the line. Although Nevada was long considered to be the metropolis of the county, Ames was the most widely known of the towns because of the busy railroad depot where travelers changed trains for all points north, south, east, and west.

In 1979, Story County consisted of 16 townships and 15 incorporated cities. The population, by special census in 1978, was 69,193. This ranked the county ninth in population among the ninety-nine Iowa counties.

Relief and Drainage

Most of the soils in Story County are nearly level to gently sloping or moderately sloping. Small areas of moderately sloping to steep soils occur throughout the county except in the northwestern part. Larger areas of steeper soils are along Indian Creek south of Nevada and along the Skunk River valley.

The Skunk River and its tributaries drain much of Story County. The Iowa River and its tributaries drain the northeastern part of the county.

The soils in about 35 percent of Story County are poorly drained or very poorly drained. Some of these soils, particularly those in the western half of the county, formed in old lakebeds or swamp basins that have little natural drainage. In these areas, drainage ditches provide outlets for drains installed underground. Many of the poorly drained and very poorly drained soils throughout the county have been artificially drained sufficiently for crop production. Other areas have insufficient underground and surface drainage for wetter-than-average years, and crops are sometimes damaged. With the increased size of farm machinery, wetness becomes more of a problem in tillage. For this reason, some of the previously drained areas need additional subsurface drainage to speed up soil drying following prolonged wet seasons.

Farming

Most of Story County is farmland. The land is used mainly for corn and soybeans, but some acreage is in pasture, oats, hay, garden crops, or woodland. Soybeans and corn are sold as cash crops. The principal livestock enterprises are hogs and beef cattle.

The trend in recent years has been toward a decrease in the number of farms in the county and an increase in their size. In 1976, the county had a total of 1,140 farms (*3*). The average farm was 298 acres.

Transportation

Four major highways serve Story County. U.S. Highway 30 traverses the county east to west. It intersects U.S. Highway 65, Interstate Highway 35, and U.S. Highway 69, all running north to south. Hard-surface state and county roads connect these highways with all the smaller communities. There are an additional 950 miles of secondary roads, primarily gravel but including some unimproved dirt roads.

Four major railroad lines serve Story County. Two of these lines run north and south, one traversing the western part of the county and another traversing the eastern and central parts of the county. Two lines run east and west, one traversing the central part of the county and another traversing the southern part. Two smaller branch lines include one that traverses the southwestern part of the county and one running east from Zearing that is presently under plans for abandonment.

Bus transportation is available from Ames in all directions. Ames also has an airport, although no commercial airlines provide scheduled service.

Climate

Prepared by the National Climatic Center, Asheville, North Carolina.

Story County is cold in winter. It is quite hot with occasional cool spells in summer. Precipitation during the winter frequently occurs as snowstorms. During the warm months there are showers, often heavy, when warm moist air moves in from the south. Total annual rainfall is normally adequate for corn, soybeans, and small grains.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Colo in the period 1964 to 1978. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 20 degrees F, and the average daily minimum temperature is 11 degrees. The lowest temperature on record, which occurred at Colo on January 16, 1977, is -28 degrees. In summer the average temperature is 71 degrees, and the average daily maximum temperature is 82 degrees. The highest recorded temperature, which occurred at Colo on July 7, 1977, is 103 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is 34 inches. Of this, 25 inches, or 75 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 21 inches. The heaviest 1-day rainfall during the period of record was 4.2 inches at Colo on August 29, 1975. Thunderstorms occur on about 50 days each year, and most occur in summer.

The average seasonal snowfall is 25 inches. The greatest snow depth at any one time during the period of record was 12 inches. On an average of 26 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible in summer and 50 percent in winter. The prevailing wind is from the northwest. Average windspeed is highest, 13 miles per hour, in spring.

Tornadoes and severe thunderstorms occur occasionally. These storms are local and of short duration, and they result in narrow belts of sparse damage. Hailstorms occur in irregular patterns and in relatively small areas at times during the warmer part of the year.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biologic activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, the landforms, relief, climate, and the natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another resulting in gradual changes in characteristics. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, acidity, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field-observed characteristics and the soil properties in terms of expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and new interpretations sometimes are developed to meet local needs. Data were assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management were assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use of require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed, and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soils on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation to precisely define and locate the soil is needed to plan for intensive uses in small areas.

General Soil Map Units

The general soil map at the back of this publication shows broad areas, called associations, that have a distinctive pattern of soils, relief, and drainage. Each soil association on the general soil map is a unique natural landscape. Typically, a soil association consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one association can occur in other associations but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

1. Clarion-Webster-Nicollet association

Nearly level to moderately sloping, well drained, poorly drained, and somewhat poorly drained, loamy soils formed in glacial till and local alluvium from till; on uplands

This association is characterized by an undulating ground moraine of swales and rises that differ from about 5 to 10 feet in elevation. Surface drainage is not well developed, and runoff water commonly accumulates in scattered depressions (fig. 2). Slopes range from 0 to 9 percent.

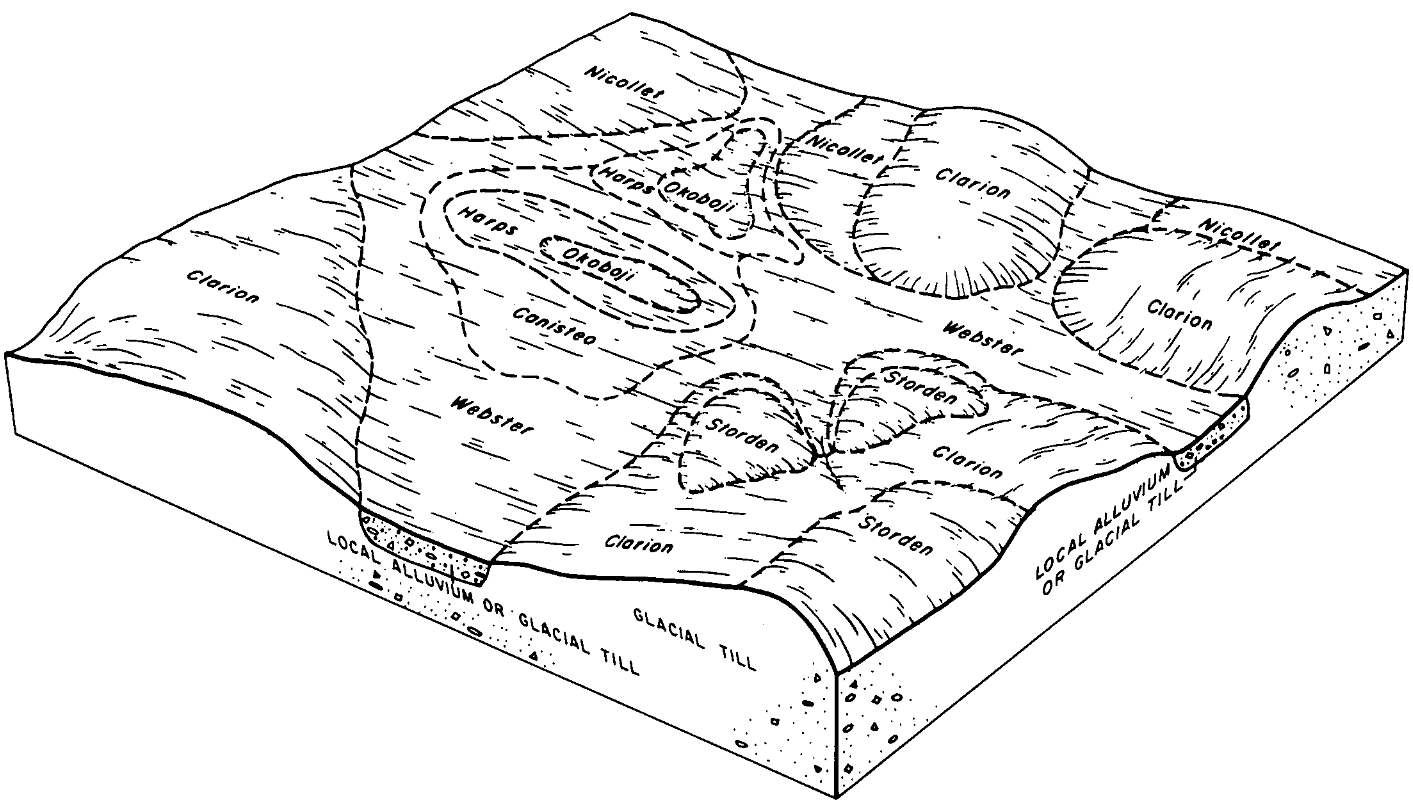


Figure 2.—Pattern of soils and parent material in the Clarion-Webster-Nicollet association.

This association makes up about 62 percent of Story County. It is about 35 percent Clarion soils, 22 percent Webster soils, 10 percent Nicollet soils, and 33 percent soils of minor extent.

Clarion soils are well drained and occur on the higher, more sloping areas. Webster soils are poorly drained and occur in low areas and drainageways. The Nicollet soils are somewhat poorly drained and occur on concave to slightly convex slopes.

Typically, the surface layer of the Clarion soils is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is brown and dark yellowish brown, friable loam about 20 inches thick. The substratum to a depth of 60 inches is light olive brown, mottled loam.

Typically, the surface layer of the Webster soils is black clay loam about 8 inches thick. The subsurface layer is black clay loam about 9 inches thick. The subsoil is very dark gray and olive gray, mottled, friable clay loam about 21 inches thick. The substratum to a depth of 60 inches is olive gray, mottled loam and sandy loam.

Typically, the surface layer of the Nicollet soils is black loam about 8 inches thick. The subsurface layer is very dark gray loam about 9 inches thick. The subsoil is dark grayish brown and light yellowish brown, mottled, friable loam about 19 inches thick. The substratum to a depth of 60 inches is grayish brown loam.

Of minor extent in this association are the well drained Lester and Storden soils, the poorly drained Canisteo and Harps soils, and the very poorly drained Okoboji and Palms soils. Lester soils occupy about the same position on the landscape as Clarion soils. Storden soils are on knobs and narrow ridges. Canisteo soils occupy about the same position on the landscape as Webster soils. Harps soils are very gently sloping and are on rims of depressions. Okoboji and Palms soils are in depressions.

Nearly all of this association is used for row crops. A few areas are timbered or in permanent pasture.

The major soils are well suited to row crops if they are properly drained and if erosion is controlled. The minor Okoboji and Palms soils are moderately suited to row crops if properly drained, but they are susceptible to ponding after heavy rains and spring thaws. A few steep areas and some sloping, gravelly areas are not suited to row crops.

Most of the poorly drained soils and many of the depressions have been drained. Contouring and terracing are complicated by the irregular topography. Controlling water erosion and removing excess water in the nearly level areas and depressions are the major management concerns.

2. Canisteo-Okoboji-Nicollet association

Level and very gently sloping, somewhat poorly drained to very poorly drained, loamy and silty soils formed in glacial till or local alluvium from till; on uplands and in upland depressions

Most of this association consists of soils in wide, very shallow swales or on flats. There are many slight, convex rises and many depressions. The natural drainage pattern in most of the association is indistinct and not well established (fig. 3). In places, however, small, sluggish streams in indistinct valleys extend into the association. Drainage ditches have been dug in these valleys to provide outlets for tile drains. The ditches generally begin in a large depression and eventually empty into larger, well defined streams. Slopes range from 0 to 3 percent.

This association occupies about 10 percent of the county. It is about 35 percent Canisteo soils, 30 percent Okoboji soils, 15 percent Nicollet soils, and 20 percent soils of minor extent.

Canisteo soils are poorly drained, calcareous soils on concave upland swales. Okoboji soils are level, very poorly drained soils in depressions. Nicollet soils are somewhat poorly drained soils in swales and on knolls.

Typically, the surface layer of the Canisteo soils is black clay loam about 10 inches thick. The subsurface layer is black silty clay loam about 13 inches thick. The subsoil is about 14 inches thick. It is dark gray, firm silty clay loam in the upper part and mixed olive gray and dark gray, friable silty clay loam in the lower part; mottles are throughout. The substratum to a depth of 60 inches is olive gray and olive, mottled clay loam in the upper part and olive gray and yellowish brown, mottled loam in the lower part. The soil is calcareous and mildly alkaline throughout the surface layer, subsurface layer, and subsoil.

Typically, the surface layer of the Okoboji soils is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 24 inches thick. The subsoil is dark gray and gray, mottled, friable silty clay loam about 15 inches thick. The substratum to a depth of about 60 inches is light gray and gray, mottled, calcareous silty clay loam.

Typically, the surface layer of the Nicollet soils is black loam about 8 inches thick. The subsurface layer is very dark gray loam about 9 inches thick. The subsoil is dark grayish brown and light yellowish brown, mottled, friable loam about 19 inches thick. The substratum to a depth of 60 inches is grayish brown, calcareous loam.

Of minor extent in this association are the gently sloping to moderately sloping Clarion soils on knolls or low hills. The highly calcareous Harps soils are on narrow rims around depressions. The very poorly drained Wacousta soils and Palms soils are in depressions.

Most of this association is used for row crops. Corn and soybeans are the major crops. The undrained depressional areas provide good wetland wildlife habitat.

Much of this association is artificially drained. Most areas are drained by tile lines, but shallow drainage ditches are used to drain some depressions, and large drainage ditches are used in places.

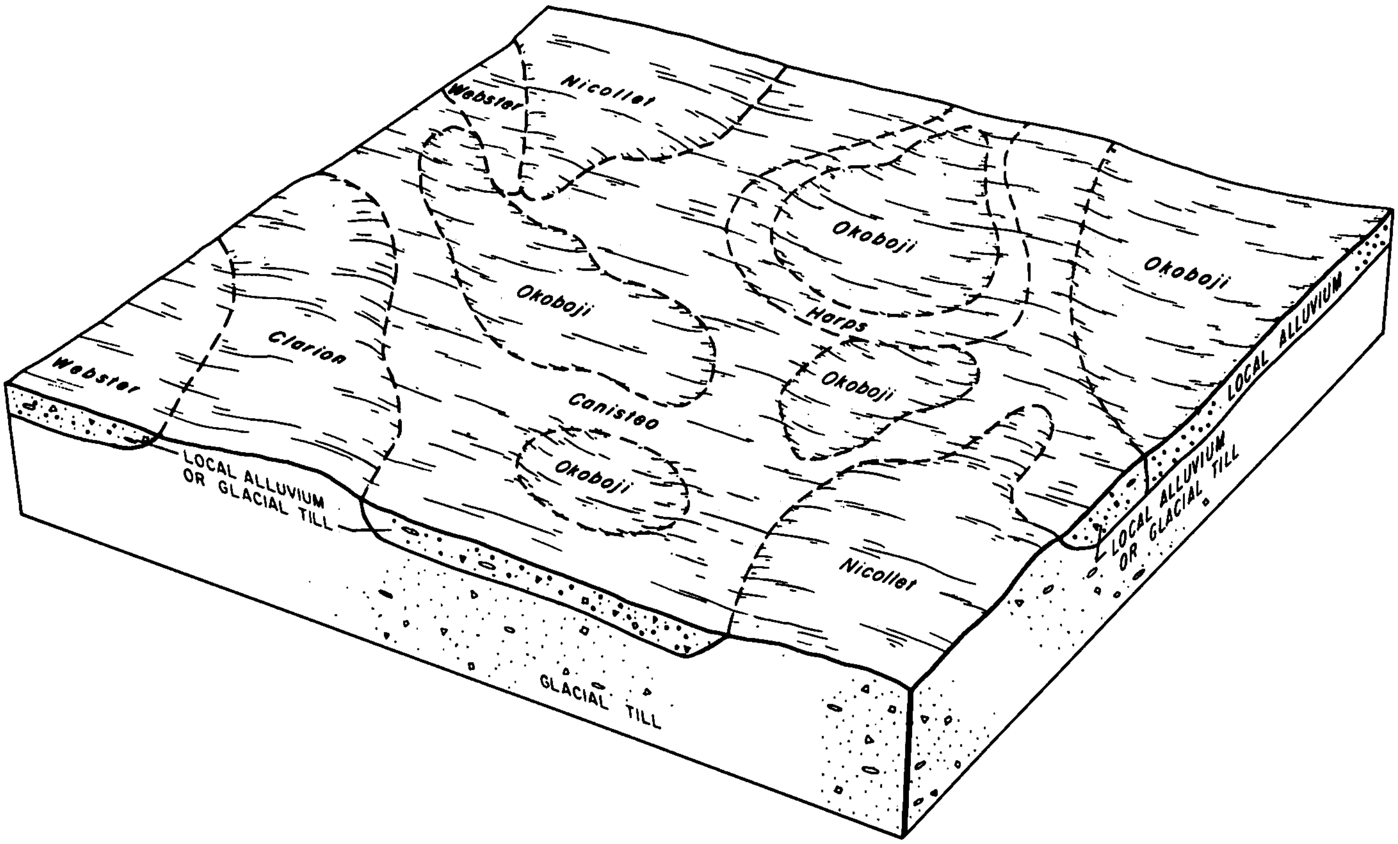


Figure 3.—Pattern of soils and parent material in the Canisteo-Okoboji-Nicollet association.

Water erosion is a hazard in a few areas. These soils commonly are plowed in the fall, and large areas are then left bare. If the surface is dry in spring and other weather conditions are appropriate, soil blowing is a serious hazard in places. Soil blowing causes road ditches to fill with soil, and cleaning these ditches generally is expensive.

3. Coland-Spillville-Zook association

Nearly level, moderately well drained to poorly drained, loamy and silty soils formed in alluvium; on bottom lands

This association is characterized by soils on alluvial flood plains. The soils in this association are subject to flooding. Open ditches and levees provide surface drainage and some flood control (fig. 4). Slopes range from 0 to 2 percent.

This association occupies about 8 percent of the county. It is about 40 percent Coland soils, 32 percent Spillville soils, 15 percent Zook soils, and 13 percent soils of minor extent.

The Coland and Zook soils are poorly drained. The Spillville soils are moderately well drained or somewhat poorly drained. All three soils are on nearly level flood plains; the Spillville soils are commonly nearest to the stream channels.

Typically, the surface layer of the Coland soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray, mottled clay loam about 39 inches thick. The substratum is olive gray clay loam.

Typically, the surface layer of the Spillville soils is black loam about 8 inches thick. The subsurface layer to a depth of 60 inches is black, very dark brown, and very dark grayish brown loam.

Typically, the surface layer of the Zook soils is black silty clay loam about 8 inches thick. The subsurface layer is black and gray, firm silty clay about 43 inches thick. The substratum to a depth of 60 inches is olive gray and olive silty clay loam.

Of minor extent in this association are the Biscay, Wadena, and Hanlon soils. The Biscay and Wadena soils are on adjacent stream terrace landscapes. The Wadena soils are generally not subject to flooding. The Hanlon soils are on the natural levee adjacent to meandering streams. They have a fine sandy loam surface layer and are somewhat droughty during extended dry periods. They are commonly flooded.

Most areas of this association are cultivated. Corn and soybeans are the main row crops. Areas that have meandering stream channels are commonly left in permanent pasture and woodland.

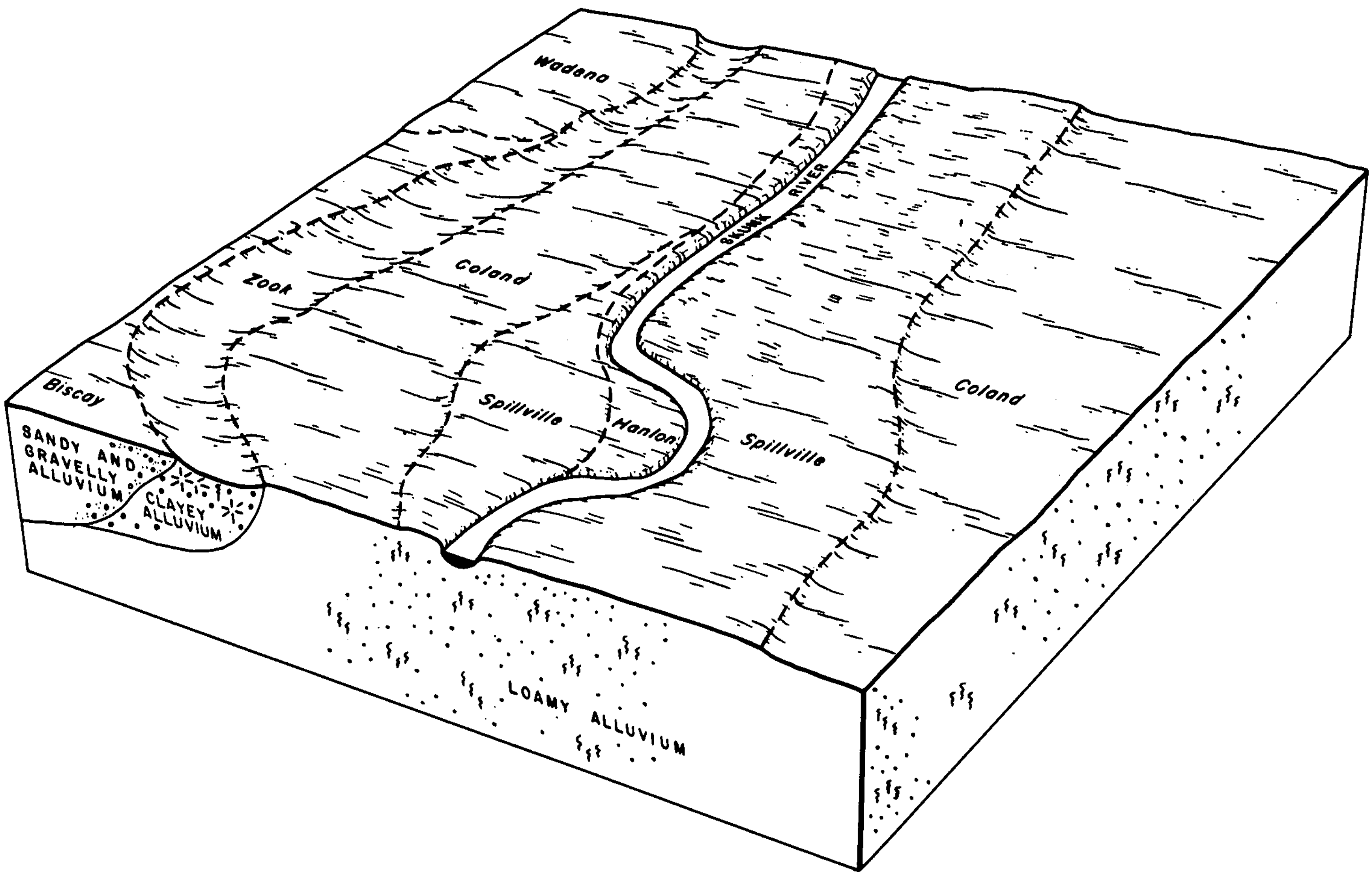


Figure 4.—Pattern of soils and parent material in the Coland-Spillville-Zook association.

The main concerns of management are flooding and surface drainage. Clearing trees and land leveling are commonly practiced in channeled areas to convert permanent pasture and woodland to row crop production. Streambank erosion is common along the major streams. Drainage ditches fill with sediment from the uplands and must be dredged frequently. Some levees and diversions are used to protect cropland from flooding.

4. Kossuth-Ottosen-Bode association

Nearly level to gently sloping, well drained, somewhat poorly drained, and poorly drained, silty and loamy soils formed in local alluvium or lacustrine sediment over glacial till; on uplands

This association is characterized by broad, nearly level areas that have many slightly convex rises and concave depressions. Most of this association consists of poorly drained soils (fig. 5). Drainage ditches and large tile systems provide outlets for drainage. Slopes range from 0 to 5 percent.

This association occupies about 3 percent of the county. It is about 57 percent Kossuth soils, 21 percent Ottosen soils, 10 percent Bode soils, and 12 percent soils of minor extent.

Kossuth soils are level, poorly drained soils on broad upland flats. They form a nearly continuous area of several thousand acres containing small islands of Ottosen and Bode soils on areas of low relief. Ottosen soils are gently sloping, somewhat poorly drained soils in swales and on knolls of gently undulating uplands. Bode soils are gently sloping, well drained soils on convex knolls.

Typically, the surface layer of the Kossuth soils is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark gray silty clay loam about 14 inches thick. The subsoil is about 13 inches thick. The upper part is dark gray, mottled, firm silty clay loam and the lower part is olive gray, mottled, firm clay loam. The substratum to a depth of 60 inches is grayish brown clay loam.

Typically, the surface layer of the Ottosen soils is black clay loam about 8 inches thick. The subsurface

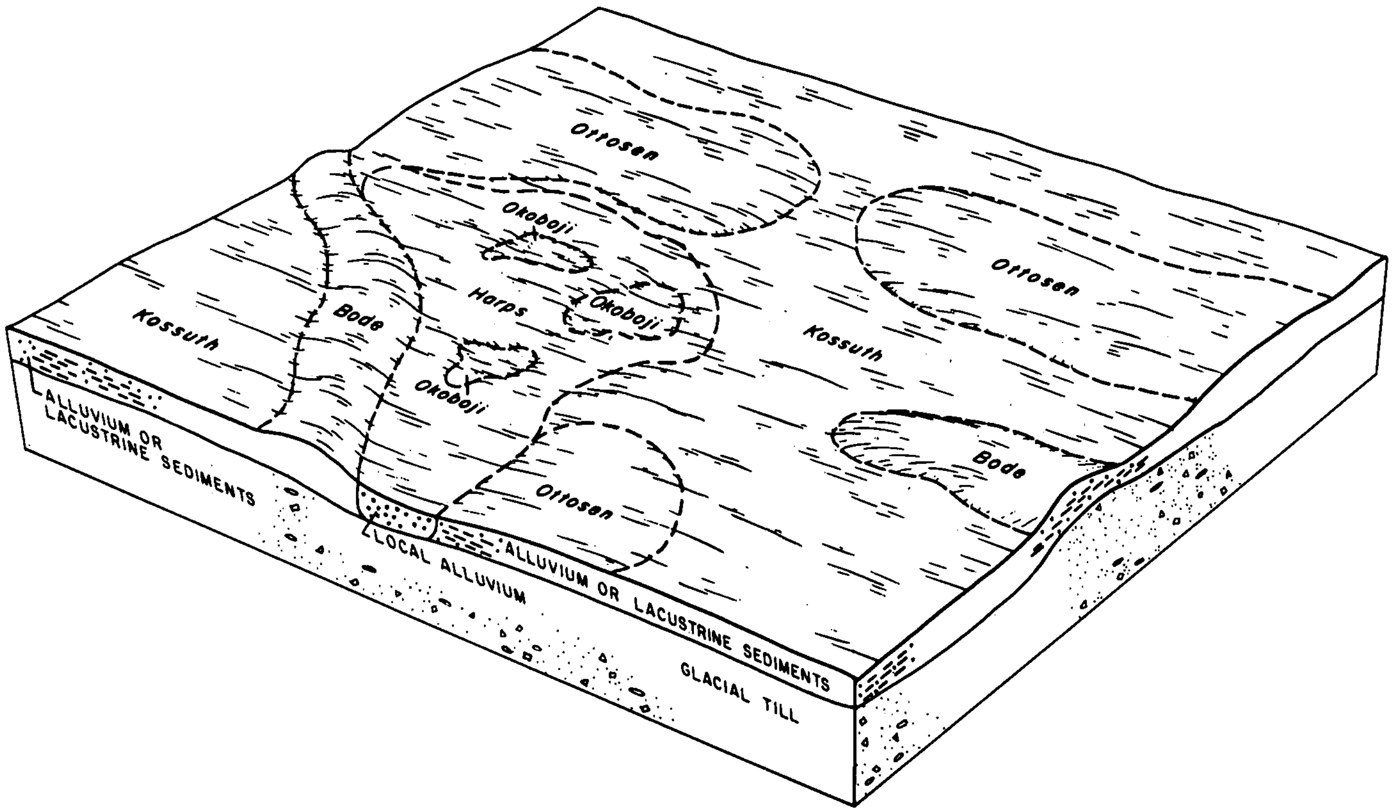


Figure 5.—Pattern of soils and parent material in the Kossuth-Ottosen-Bode association.

layer is black and very dark grayish brown clay loam about 10 inches thick. The subsoil is dark grayish brown, friable clay loam about 17 inches thick. The substratum to a depth of 60 inches is dark grayish brown and olive gray, mottled loam.

Typically, the surface layer of the Bode soils is black and very dark grayish brown clay loam about 8 inches thick. The subsurface layer is very dark grayish brown clay loam about 4 inches thick. The subsoil is firm clay loam about 22 inches thick. It is olive brown in the upper and middle parts and light olive brown in the lower part. The substratum to a depth of 60 inches is light olive brown, mottled loam.

Of minor extent in this association are the Canisteo, Harps, and Okoboji soils. The very poorly drained Okoboji soils are in depressions. The highly calcareous, poorly drained Harps soils are on rims around depressions of this association. The mildly calcareous, poorly drained Canisteo soils also surround some of the depressions.

Most areas of this association are used for row crops. Corn and soybeans are the major crops.

Much of this association needs artificial drainage. Most areas are drained by tile lines and some by drainage ditches. Surface drains and tile intakes are used to remove ponded water from depressions. Wind erosion is a hazard in this association. If soils are plowed in the fall and large areas then left bare, snow and soil blowing from such areas can cause ditches beside roads and in farmsteads to fill with snow or soil.

5. Clarion-Storden-Coland association

Nearly level to steep, well drained and poorly drained, loamy soils formed in glacial till or alluvium; on uplands and bottom lands

This association is characterized by dissected glacial moraine areas. These areas consist of side slopes, knolls, ridgetops, and flood plains (fig. 6). Surface drainage is well developed. Slopes range from 1 to 25 percent.

This association occupies about 9 percent of the county. It is about 45 percent Clarion soils, 35 percent Storden soils, 10 percent Coland soils, and 10 percent soils of minor extent.

Gently sloping or moderately sloping, well drained Clarion soils are on convex knolls and ridgetops. Clarion soils on side slopes are dominantly moderately sloping or strongly sloping. Storden soils are strongly sloping to steep, well drained soils on knobs, ridgetops, and

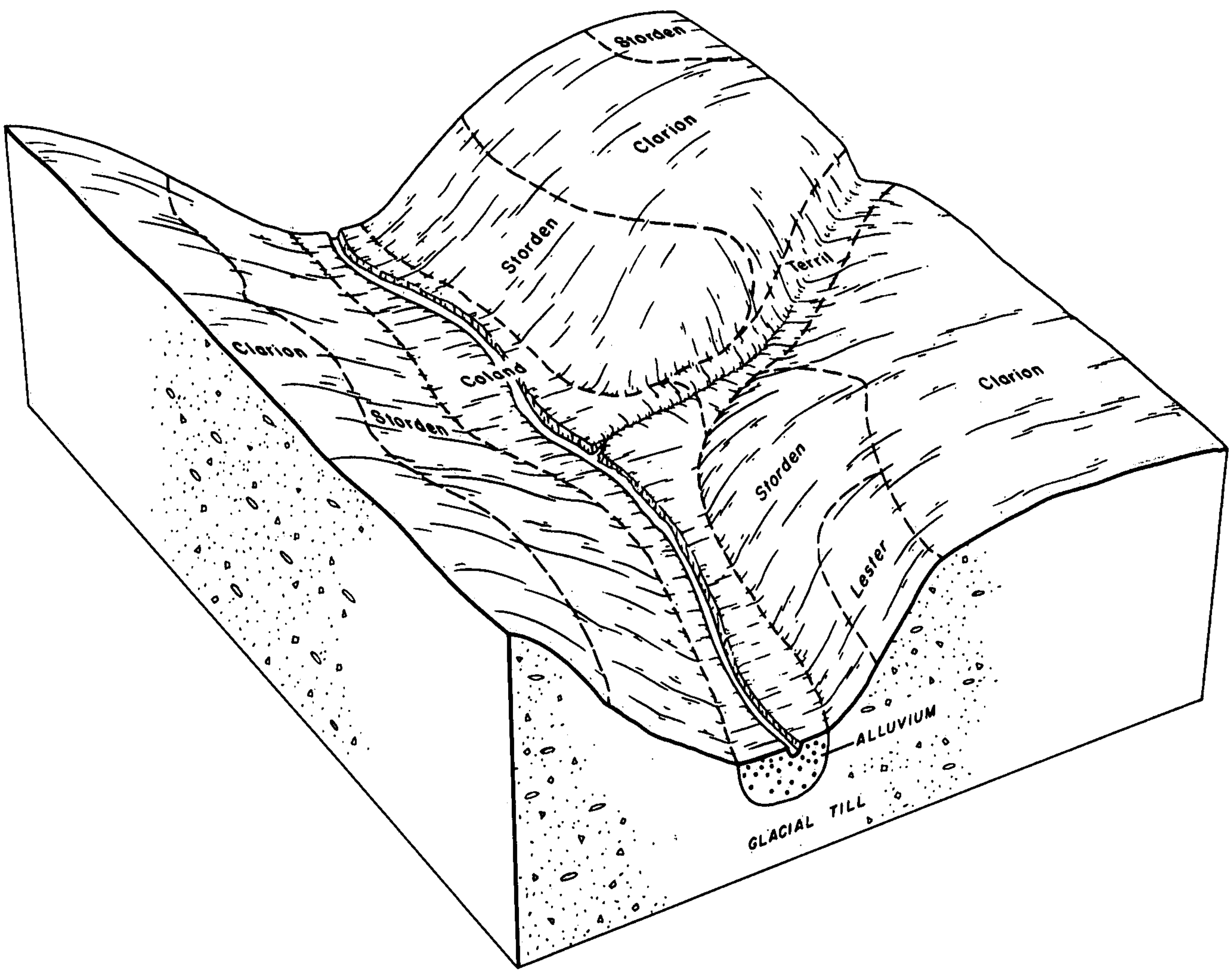


Figure 6.—Pattern of soils and parent material in the Clarion-Storden-Coland association.

shoulders of side slopes. The Coland soils are nearly level, poorly drained soils on upland drainageways.

Typically, the surface layer of the Clarion soils is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is friable loam about 20 inches thick. The upper and middle parts are brown and the lower part is yellowish brown. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous loam.

Typically, the surface layer of the Storden soils is dark grayish brown, calcareous loam about 8 inches thick. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous loam.

Typically, the surface layer of the Coland soils is black clay loam about 8 inches thick. The subsurface layer is black and gray, mottled clay loam about 39 inches thick. The substratum to a depth of about 60 inches is olive gray clay loam.

Of minor extent in this association are the Webster, Nicollet, Lester, and Terril soils. The Webster soils occupy drainageways and swale positions. Nicollet soils are at the head of drainageways or on slightly convex knolls. Lester soils occupy landscape positions similar to those of the Clarion soils but formed under mixed forest and prairie vegetation. Terril soils occupy the colluvial foot slope position below the Clarion and Storden soils and adjacent to the Coland soils.

Many of the ridgetops and some of the side slopes of this association are cultivated. Corn and soybeans are the main row crops. Because of steep side slopes and drainageways that are uncrossable with tillage implements (fig. 7), much of this association is in permanent pasture and woodland. The narrow drainageways that have steep side slopes are potential sites for ponds.

Figure 7.—A typical landscape of Clarion-Storden-Coland association. The watercourse dissecting this landscape is uncrossable by tillage implements.

Rill and sheet erosion on cultivated land and gully erosion in the drainageways are the major concerns.

6. Hayden-Lester-Storden association

Gently sloping to very steep, well drained, loamy soils formed in glacial till; on uplands

This association is characterized by dissected glacial moraine areas. These areas consist of ridgetops and convex side slopes. Drainageways, streams, and gullies dissect this association (fig. 8). Many areas have escarpments and very steep bluffs adjacent to the flood plain and stream channels. Slopes range from 2 to 50 percent.

This association occupies about 7 percent of the county. It is about 35 percent Hayden soils, 25 percent Lester soils, 20 percent Storden soils, and 20 percent other soils.

Hayden soils are gently sloping to very steep, well drained soils on upland side slopes adjacent to major streams. Most areas of Hayden soils are dissected by many gullies and deep drainageways. Lester soils are gently sloping to steep, well drained soils on knolls, on ridgetops, and on convex side slopes that border streams and upland drainageways. Storden soils are moderately sloping to very steep, well drained soils on escarpments and on convex side slopes that border streams and upland drainageways.

Typically, the surface layer of the Hayden soils is very dark grayish brown, friable loam about 3 inches thick. The subsurface layer is dark grayish brown, friable loam about 5 inches thick. The subsoil is about 45 inches thick. The upper part is brown, friable loam, and the middle and lower parts are dark yellowish brown and yellowish brown friable loam and clay loam. The substratum to a depth of 60 inches is yellowish brown, mottled loam.

Typically, the surface layer of the Lester soils is very dark grayish brown loam about 8 inches thick. The subsurface layer is dark grayish brown loam about 3 inches thick. The subsoil is dark yellowish brown and brown, friable loam about 44 inches thick. The substratum is light olive brown loam.

Typically, the surface layer of the Storden soils is very dark brown loam about 9 inches thick. The subsurface layer is very dark grayish brown and yellowish brown loam about 8 inches thick. The substratum to a depth of 60 inches is yellowish brown, mottled, calcareous loam.

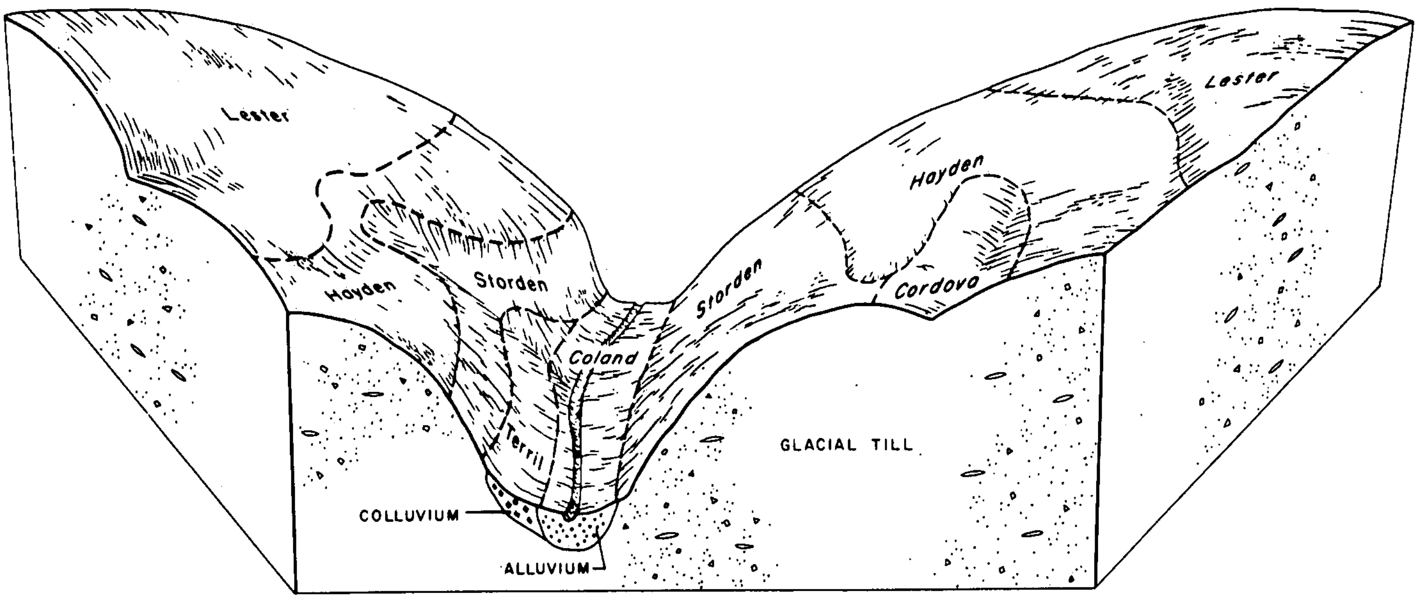


Figure 8.—Pattern of soils and parent material in the Hayden-Lester-Storden association.

Of minor extent in this association are the Cordova and Rolfe soils. Cordova soils are in concave swales and drainageways on the upland ridge crest. Rolfe soils are in depressions on upland ridge crests.

Most of this association is used for pasture and woodland. The gently sloping and moderately sloping Hayden and Lester soils on ridge crests are suited to row crops. The steeper Hayden, Lester, and Storden soils on side slopes are better suited to permanent pasture and woodland.

The main concerns of management are controlling water erosion on cultivated areas of the ridge crests and gully erosion in the waterways. Where streambank erosion occurs at the base of escarpments, soil slippage and slides are common.

7. Sparta-Dickinson-Farrar association

Nearly level to strongly sloping, excessively drained to well drained, sandy and loamy soils formed in eolian, alluvial, and glacial till sediment; on uplands and stream terraces

This association is characterized by dune-like landscapes along the bluffs of major streams and on stream benches. Slopes range from 0 to 14 percent (fig. 9).

This association occupies about 1 percent of the county. It is about 40 percent Sparta soils, 25 percent Dickinson soils, 20 percent Farrar soils, and 15 percent soils of minor extent.

Sparta soils are gently sloping to strongly sloping, excessively drained soils on convex ridge crests on uplands and stream terraces. Dickinson soils are nearly level and moderately sloping, somewhat excessively drained soils on slightly convex areas on stream terraces and uplands. Farrar soils are gently sloping, well drained soils on convex knolls and ridges.

Typically, the surface layer of the Sparta soils is very dark grayish brown loamy fine sand about 9 inches thick. The subsurface layer is brown loamy fine sand about 7 inches thick. The subsoil is very friable loamy fine sand about 23 inches thick. The upper part is dark yellowish brown, and the lower part is brown. The substratum to a depth of 60 inches is brown sand.

Typically, the surface layer of the Dickinson soils is very dark brown fine sandy loam about 8 inches thick. The subsurface layer is very dark brown fine sandy loam about 9 inches thick. The subsoil is about 23 inches thick. The upper part is very dark grayish brown, very friable sandy loam; the middle part is brown, very friable fine sandy loam; and the lower part is dark yellowish brown, very friable loamy fine sand. The substratum to a depth of about 60 inches is variegated sand.

Typically, the surface layer of the Farrar soils is very dark brown fine sandy loam about 7 inches thick. The subsurface layer is very dark brown fine sandy loam about 7 inches thick. The subsoil extends to a depth of 39 inches. It is brown, very friable sandy loam in the upper part; dark yellowish brown, friable loam in the middle part; and yellowish brown, friable loam in the lower part. The substratum to a depth of 60 inches is light brown loam.

Of minor extent in this association are the Ankeny and Storden soils. Ankeny soils occupy the foot slopes and alluvial fans. Storden soils occupy the eroded shoulder slopes on the nose slopes and side slopes of the interfluves.

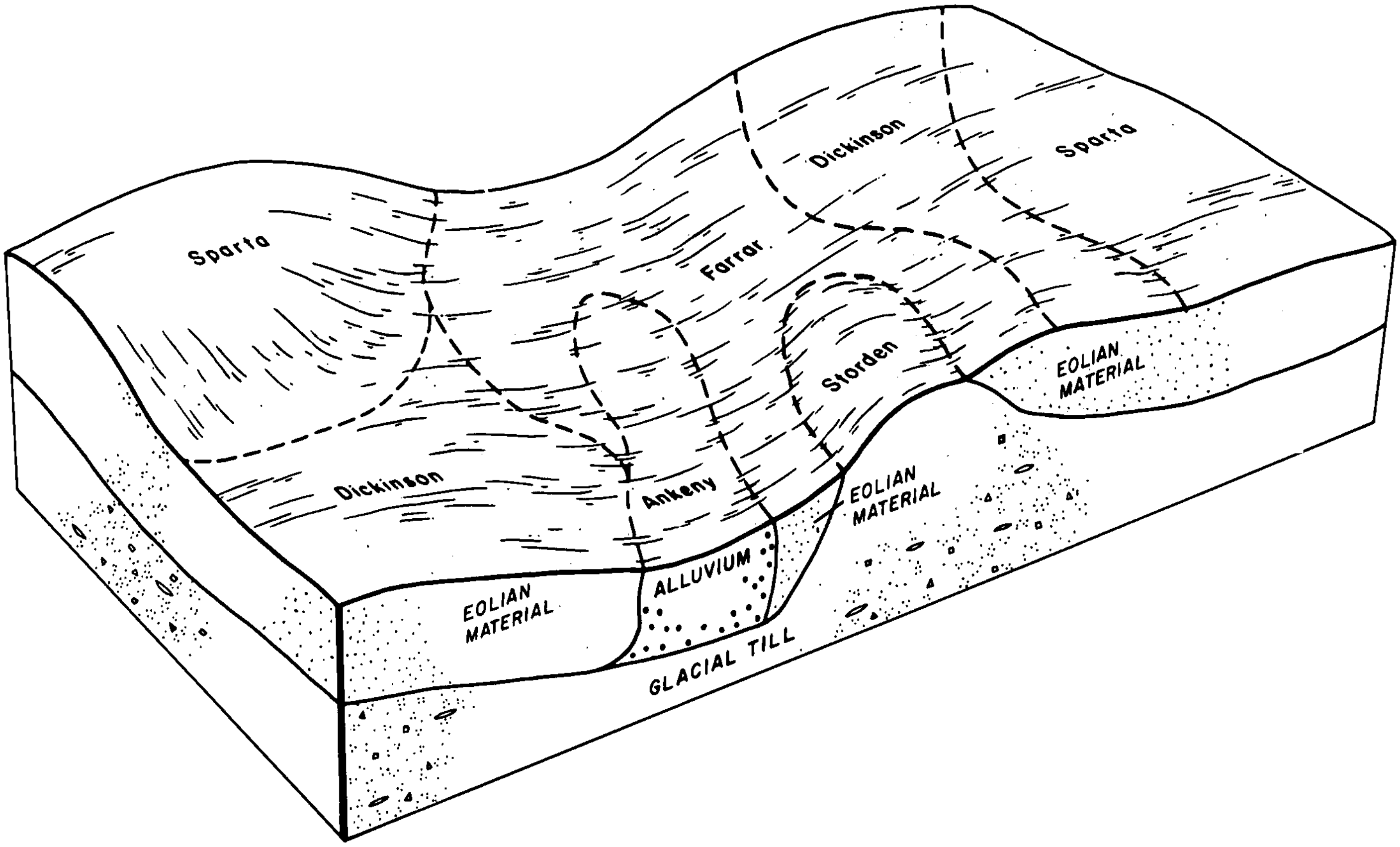


Figure 9.—Pattern of soils and parent material in the Sparta-Dickinson-Farrar association.

Much of this association is cultivated or is in pasture or hayland. Corn and soybeans are the main row crops. Alfalfa, red clover, and bromegrass are the main forage crops. Woodland and nursery stock production is practiced on some of these soils.

These soils are best suited to woodland or forage and pasture production. The available water capacity is limiting for row crop production of corn and soybeans. Soil blowing and rill erosion are serious problems on cultivated areas of this association.

Broad Land Use Considerations

Story County has a wide variety of soils, each of which is suitable for a particular use. The county's soils are on upland nearly level areas, on gently sloping to steep ridges or side slopes, in former marsh areas, and in stream valleys. Many of the soils are well drained and deep. A few soils are shallow to sand or gravel. Some soils have few limitations; others are very erosive if tilled. Some soils are naturally wet; others are droughty or are subject to flooding. Each kind of soil has attributes that determine its best use.

Many areas of Story County are well suited to grain production and are used for that purpose. A much smaller acreage is best used as pasture or woodland or for close growing crops, wildlife habitat, or recreational areas. The general soil map of Story County divides the county into seven soil associations for broad land use planning. Each association is a unique natural landscape with a distinct pattern of soils, relief, and drainage.

The soils in associations 1, 2, and 4 have few limitations for farming. Fields are generally large and suitable for cultivation. Corn and soybeans are the main crops. Where erosion and drainage needs are met, these soils are in optimal use.

Soil associations 1 and 4 formerly contained many ponds and marshes. These were drained with ditches and large tile in the early part of this century as land became more valuable. Although the soil is drained sufficiently for tillage, some of the drainage systems need improvement if the grain production potential is to be realized.

Soil association 3 contains many of the county's rivers and streams and the adjacent bottom land and terrace soils. Much of the woodland in the county is in these frequently flooded bottom lands. The streams in this area naturally meander, frequently cutting new channels. They serve as drainageways for floodwater and for normal surface runoff. In places, where channels have been straightened, wildlife habitat is destroyed and cropland of only marginal value is developed. Many of the soils on the stream terraces are somewhat droughty. Although they are generally suited to intensive grain production, yields are not as consistently high as on the deeper soils that have a higher available water capacity.

Soil associations 5 and 6 are more sloping and more dissected by small streams and waterways than those previously mentioned. Fields are commonly smaller. Small areas unsuited to cultivation are left to grass and woodland. These landscape features generally make the soils less suited to intensive grain production and better suited to livestock farming than soils in other associations. The woods and grassland furnish favorable habitat for wildlife. These soils are also suited to such recreational uses as hunting, hiking, and nature study.

Soil association 5 consists dominantly of moderately sloping to steep, well drained soils that formed in glacial drift. These soils are not generally suited to intensive grain production. The largest area of these soils is near the Skunk River and Indian Creek. Many of the slopes are long and border narrow, wet waterways. The steeper soils are frequently wooded. Some of the better farm ponds and recreational areas are in this association.

Soil association 6 consists of a series of hills that have gently sloping crests and moderately sloping to steep side slopes. It also contains narrow waterways and good sites for recreational impoundments. In some sandy areas, however, water can leak from ponds unless special construction measures are used. Erosion is a severe problem where many of the soils are tilled. Streambank erosion is a problem along many very steep escarpments of this association.

Soil association 7 consists of soils formed in eolian sand deposits. Wind erosion is a severe problem where many of the soils are tilled. Tree nurseries and tree plantings provide cover and protect these soils from wind. These soils are well suited to woodland production. The soils are droughty and are not well suited to row crop production.

Soil associations 5, 6, and 7 contain a high percentage of land well suited to residential development and poorly suited to row crop production. Soil associations 1 through 4 contain a high percentage of prime agricultural land that should be preserved.

Detailed Soil Map Units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and Management of the Soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the underlying material, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the underlying material. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Clarion loam, 5 to 9 percent slopes, moderately eroded, is one of several phases in the Clarion series.

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Harps-Okoboji complex, 0 to 2 percent slopes, is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. The included soils are identified in each map unit description. Some small areas of strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Urban land is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

6—Okoboji silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions. It is subject to ponding. Individual areas dominantly are 2 to 10 acres and are elliptical, but some areas range to 50 acres.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 24 inches thick. The subsoil is dark gray and gray, mottled, friable silty clay loam about 15 inches thick. The substratum to a depth of about 60 inches is light gray and dark gray, mottled, calcareous silty clay loam. In places, the substratum is olive gray silty clay loam and is at a depth as shallow as 24 inches. In other places, the substratum is stratified and is dominantly loam or silt loam.

Included with this soil in mapping are small areas of calcareous Harps soils on low knolls or rims of depressions. These soils make up less than 5 percent of the map unit.

Permeability of this Okoboji soil is moderately slow, and surface runoff is slow or ponded (fig. 10). This soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 9 to 12 percent in the surface layer. This soil has high shrink-swell potential. Typically, the surface layer is neutral and the subsurface layer and subsoil are neutral or mildly alkaline. The subsoil generally is very low in available phosphorus and potassium.

Most areas of this soil are cultivated. If adequately drained, the soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Surface intakes remove ponded water. Tile drains improve internal drainage by removing subsurface

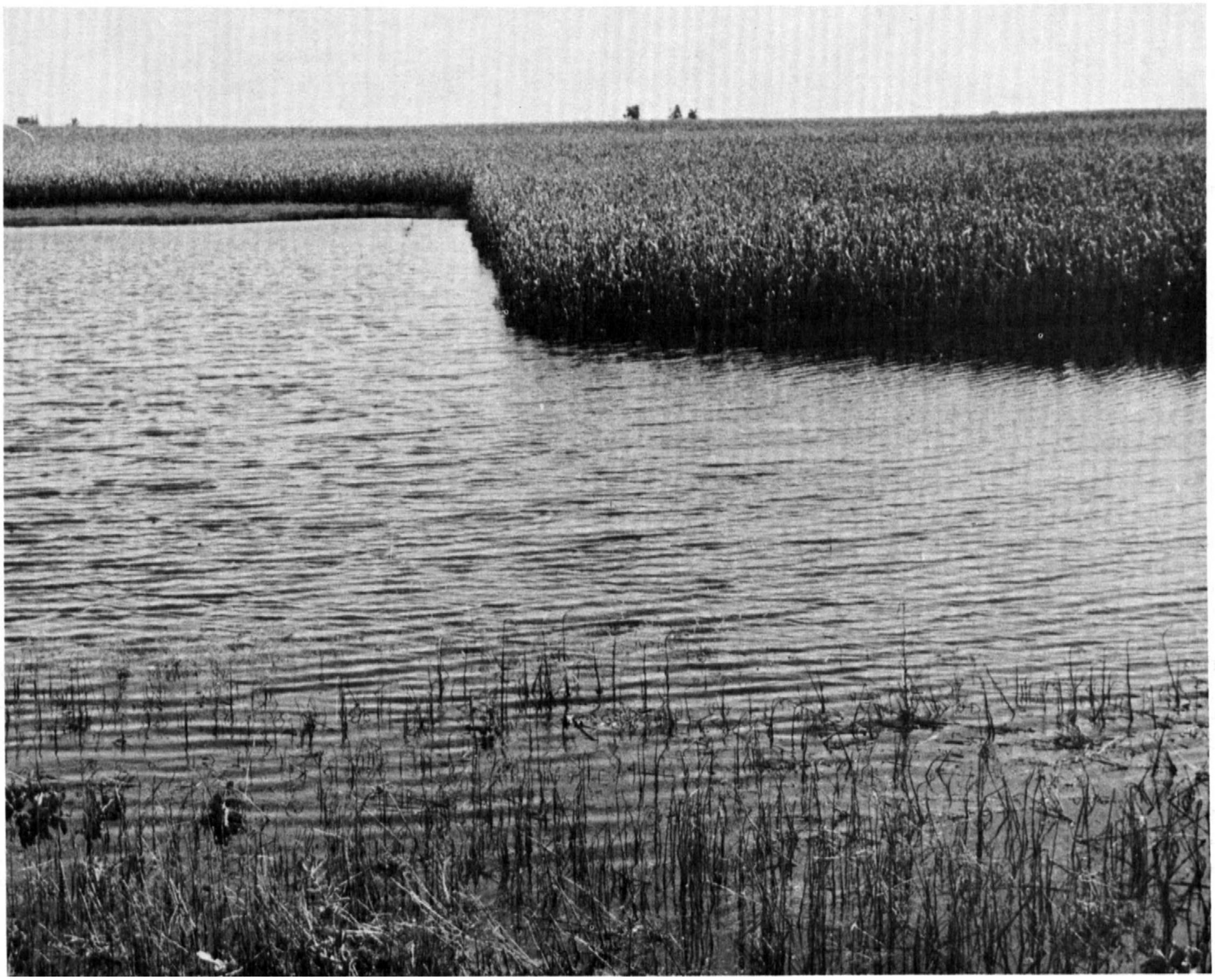


Figure 10.—Ponded water on an area of Okoboji soils in September. This area is being used for corn and as set-aside land.

water. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth. Cultivating when this soil is too wet causes compaction and cloddiness.

Wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. An adequate drainage system and the selection of species that can withstand wetness are very important.

This Okoboji soil is in capability subclass IIIw.

27B—Terril loam, 2 to 5 percent slopes. This gently sloping, moderately well drained soil is on foot slopes that are downslope from strongly sloping or very steep soils and on convex alluvial fans. Slopes generally are short. Typical areas are 2 to 5 acres and are irregular or elongated. A few areas are somewhat larger.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown loam about 24 inches thick. The subsoil extends to a depth of 60 inches. It is dark brown, friable loam in the upper part and brown, friable clay loam in the lower part.

Included with this soil in mapping are small areas of soils that are wet and seep water in the spring. These soils are on similar landscape positions as this Terril soil and make up about 5 percent of the map unit.

This Terril soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 4.5 to 5.5 percent in the surface layer. Typically, the soil is slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas of this soil are cultivated, but some areas are in pasture. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is an erosion hazard. Conservation tillage, a practice that leaves all or part of the crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. In places, contouring and terracing are difficult because of irregular topography and short slopes. Returning crop residue or other organic material helps to improve fertility, reduce surface crusting, and increase the infiltration rate.

This soil has a moderate erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to reduce erosion.

This Terril soil is in capability subclass IIe.

27C—Terril loam, 5 to 9 percent slopes. This moderately sloping, moderately well drained soil is on slightly concave foot slopes. Individual areas range from 2 to 10 acres and are long and narrow.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown, friable loam about 24 inches thick. The subsoil extends to a depth of about 60 inches. It is dark brown, friable loam in the upper part and brown, friable clay loam in the lower part. In places, the surface soil is thinner and has lower content of organic matter.

This Terril soil is moderately permeable, and surface runoff is medium. The soil receives runoff from soils that are upslope. The available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. Typically, the surface layer is neutral or slightly acid. The subsoil is very low in available phosphorus and potassium.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. In places, diversion terraces can be used to protect this soil from runoff and the resulting rills and gullies. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth.

This soil has a moderate erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to reduce erosion.

This Terril soil is in capability subclass IIIe.

34C—Estherville sandy loam, 2 to 9 percent slopes. This gently sloping and moderately sloping, somewhat excessively drained soil is on knolls, convex side slopes, and stream terraces. Slopes typically are short. Individual areas range from 2 to 10 acres and are irregular.

Typically, the surface layer is very dark grayish brown and dark brown sandy loam about 9 inches thick. The subsoil is dark yellowish brown and brown, very friable sandy loam about 7 inches thick. The substratum to a depth of about 60 inches is brown, light olive brown, and yellowish brown, loose, calcareous sand and gravel.

Permeability of this Estherville soil is moderately rapid in the solum and rapid in the substratum. Surface runoff is slow. The available water capacity is low. The content of organic matter is about 0.5 to 2.0 percent in the surface layer. Typically, this soil is slightly acid or neutral throughout. The subsoil generally is very low in available phosphorus and potassium.

Most areas of this soil are cultivated, but some areas are left as wildlife areas and are not tilled. Some areas are in pasture. This soil is poorly suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. It is droughty because of the gravelly substratum. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive moisture and soil loss. In places, contouring is used to control erosion. Returning crop residue or regularly adding other organic material helps to improve fertility, conserve moisture, and reduce soil erosion. Overgrazing reduces the protective vegetative cover and results in increased runoff and soil erosion.

This soil has a severe drought hazard and a slight erosion hazard if it is used for trees and shrubs grown as windbreaks, ornamental plantings, or wildlife plantings. Plantings should be limited to species that can survive in droughty soils.

This Estherville soil is in capability subclass IIIs.

41B—Sparta loamy fine sand, 2 to 5 percent slopes. This gently sloping, excessively drained soil is on convex ridge crests on uplands and stream terraces. Individual areas range from 2 to 20 acres and are long and narrow.

Typically, the surface layer is very dark grayish brown loamy fine sand about 9 inches thick. The subsurface layer is brown loamy fine sand about 7 inches thick. The subsoil is very friable loamy fine sand about 23 inches thick. The upper part is dark yellowish brown, and the lower part is brown. The substratum to a depth of about

60 inches is brown sand. In places, this soil has a thin, brown surface layer. In other places, the subsoil has more clay and less sand.

This Sparta soil is rapidly permeable. Surface runoff is slow. The available water capacity is low. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer typically is acid if not limed within the past 5 years. The subsoil is very low in available phosphorus and potassium.

Most areas of this soil are cultivated or in pasture. This soil is moderately suited to small grains and to grasses and legumes for hay and pasture. Drought is a severe limitation for corn and soybean production on this soil.

If this soil is used for cultivated crops, there is a hazard of wind erosion and water erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and stripcropping help to prevent excessive soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility. Pasture and hay are effective in controlling erosion.

This soil is well suited to trees and is used for tree nurseries in some areas of the county. Seedling mortality is high because of droughtiness. Seedlings should be closely spaced when planted and later thinned to achieve the desired stand density.

This soil is in capability subclass IVs.

41C—Sparta loamy fine sand, 5 to 9 percent slopes. This moderately sloping, excessively drained soil is on convex ridge crests on uplands and stream terraces. Individual areas range from 2 to 10 acres and are long and narrow.

Typically, the surface layer is very dark grayish brown loamy fine sand about 9 inches thick. The subsurface layer is dark brown, very friable loamy fine sand about 7 inches thick. The subsoil is very friable loamy fine sand about 23 inches thick. It is dark yellowish brown in the upper part and brown in the lower part. The substratum to a depth of about 60 inches is brown sand. In places, this soil has a thin, brown surface layer that is lower in content of organic matter. Also in places, the subsoil has more clay and less sand.

This Sparta soil is rapidly permeable, and surface runoff is slow. The available water capacity is low. The content of organic matter is about 0.5 to 1 percent in the surface layer. Typically, the surface layer is acid if not limed during the past 5 years. The subsoil is very low in available phosphorus and potassium. Soil tilth is good.

Most areas of this soil are cultivated or in pasture. This soil is moderately suited to small grains and to grasses and legumes for hay and pasture. Drought is a severe limitation for corn and soybean production on this soil. If this soil is used for cultivated crops, there is a hazard of wind erosion and water erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, contouring, and stripcropping help to prevent excessive soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility. Pasture and hay are also effective in controlling erosion.

This soil is well suited to trees and is used for tree nurseries in some areas. Seedling mortality is high because of droughtiness. Seedlings should be spaced closer together when planted and thinned later to achieve the desired stand density.

This Sparta soil is in capability subclass IVs.

41D—Sparta loamy fine sand, 9 to 14 percent slopes. This strongly sloping, excessively drained soil is on convex ridge crests on uplands and stream terraces. Individual areas range from 2 to 10 acres and are long and narrow.

Typically, the surface layer is very dark grayish brown loamy fine sand about 7 inches thick. The subsurface layer is dark brown loamy fine sand about 7 inches thick. The subsoil is very friable loamy sand about 23 inches thick. The upper part is dark yellowish brown, and the lower part is brown. The substratum to a depth of about 60 inches is brown sand. In places, this soil has a thin, brown surface layer that is lower in content of organic matter.

Included with this soil in mapping are small areas of less droughty Storden soil on similar landscape positions. These areas make up less than 15 percent of this map unit.

This Sparta soil is rapidly permeable, and surface runoff is medium. The available water capacity is low. The content of organic matter is about 0.5 to 1 percent in the surface layer. Typically, the surface layer is acid if not limed during the past 5 years. The subsoil is very low in available phosphorus and potassium. Soil tilth is good.

Most areas of this soil are cultivated or in pasture. This soil is generally unsuitable for cultivated crops because of the severe erosion hazard and low available water capacity. It is better suited to grasses and legumes for hay and pasture. Pasture and hay are effective in controlling erosion.

This soil is well suited to trees and is used for tree nurseries in some areas. Seedling mortality is high because of droughtiness. Seedlings should be spaced closer together when planted and thinned later to achieve the desired stand density.

This Sparta soil is in capability subclass VIs.

52B—Bode clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on knolls and on convex side slopes that border upland drainageways. Slopes typically are short. Individual areas range from 2 to 5 acres and are irregular in shape.

Typically, the surface layer is black and very dark grayish brown, friable clay loam about 8 inches thick. The subsurface layer is very dark grayish brown, friable clay loam about 4 inches thick. The subsoil is firm clay loam about 22 inches thick. It is olive brown in the upper and middle parts and light olive brown and mottled in the lower part. The substratum to a depth of about 60 inches is light olive brown, mottled, friable loam.

This Bode soil is moderately permeable, and surface runoff is rapid or medium. The available water capacity is high. The content of organic matter is about 3 or 4 percent in the surface layer. Typically, the surface layer and the upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low or low in available phosphorus and very low in available potassium.

Most areas of this soil are cultivated. If erosion is controlled, the soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Conservation tillage, a practice that leaves all or part of the crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult in places because of undulating topography and short slopes, but in most places these practices are practical. It generally is easy to maintain good tilth. The use of crop residue or other organic material helps to improve fertility, reduce soil erosion and crusting, and increase the infiltration rate.

This soil has a slight erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to control erosion.

This Bode soil is in capability subclass IIe.

54—Zook silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on low, flat flood plains. Areas of this soil are subject to flooding. Individual areas range from 5 to 120 acres and are broad and irregular in shape.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark gray silty clay loam and silty clay about 43 inches thick. The substratum to a depth of about 60 inches is olive gray and olive silty clay loam.

Included with this soil in mapping are small areas of Spillville and Hanlon soils on similar landscape positions. These areas contain more sand and less clay and make up about 5 percent of this map unit.

This Zook soil is slowly permeable, and surface runoff is slow or very slow. This soil has a seasonal high water table. The available water capacity is high. Areas of this soil receive runoff and are commonly flooded. The content of organic matter is about 5 to 7 percent in the surface layer. This soil has high shrink-swell potential. The surface layer is slightly acid or neutral. The subsoil is low in available phosphorus and very low in available potassium. This soil has poor tilth.

Most areas of this soil are cultivated. This soil is well suited to cultivated crops if drainage is adequate. Areas can be drained by tile and surface drains if adequate outlets are available. Diversions, levees, and channel improvements are practices used to control flooding and runoff from adjacent areas. Artificial drainage improves the timeliness of field operations and improves soil tilth. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth.

A high water table and flooding are the main limitations if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. It is important to select species that withstand wetness and flooding.

This Zook soil is in capability subclass IIw.

55—Nicollet loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slightly convex or plane slopes on knolls and swales. Some areas make up an entire knoll or swale. Typical areas are 2 to 15 acres and are oblong.

Typically, the surface layer is black, friable loam about 8 inches thick. The subsurface layer is very dark gray clay loam about 9 inches thick. The subsoil, about 19 inches thick, is dark grayish brown and light yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is grayish brown, mottled loam.

Included with this soil in mapping are some small areas of very poorly drained Okoboji soils in depressions that pond water. Also included are small areas of well drained Clarion soils on humps and poorly drained Webster soils on swales. These soils make up about 5 percent of the map unit.

This Nicollet soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. Typically, the surface layer and the upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas of this soil are cultivated. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Tile drains help to avoid delays in field operations. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. The use of crop residue or other organic material helps to reduce wind erosion and crusting and increase the infiltration rate. Cultivation or grazing when the soil is too wet causes compaction.

This Nicollet soil is in capability class I.

62C3—Storden loam, 5 to 9 percent slopes, severely eroded. This moderately sloping, well drained, calcareous soil is on knolls and convex side slopes that border streams and upland drainageways. Slopes generally are short. Individual areas range from 2 to 10 acres and are irregular in shape or are elongated. Some individual areas are larger.

Typically, the surface layer is dark grayish brown, calcareous, friable loam about 8 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous loam.

Included with this soil in mapping are small sandy or gravelly knobs. These areas make up less than 5 percent of the map unit.

This Storden soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is less than 0.5 percent in the surface layer. Typically, the soil is moderately alkaline throughout. Below the surface layer, the available phosphorus and potassium generally are very low. Typically, it is easy to maintain good tilth.

Most areas of this soil are cultivated. If erosion is controlled and fertility is improved, this soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. This soil has a severe erosion hazard. Conservation tillage, a practice that leaves all or part of the residue on the surface, and grassed waterways help to prevent excessive soil loss. In places, contouring and terracing are difficult because of short slopes; in most places, however, these practices are suited. Larger additions of phosphorous and potassium fertilizers are needed because of the high lime content of the soil. Soybeans may also require additions of iron compounds. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce soil erosion and crusting, and increase the infiltration rate.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks or ornamental plantings. A mulch cover helps to deter erosion.

This Storden soil is in capability subclass IIIe.

62D—Storden loam, 9 to 14 percent slopes. This strongly sloping, well drained soil is on convex side slopes in uplands. The slopes typically are short. Individual areas range from 2 to 5 acres and are long and narrow.

Typically, the surface layer is very dark brown, calcareous, friable loam about 9 inches thick. The subsurface layer is very dark grayish brown and dark yellowish brown, calcareous loam about 8 inches thick. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam.

Included with this soil in mapping are a few small areas of Zenor soil on high knolls. The Zenor soil contains more sand and gravel and is droughty. These areas make up less than 5 percent of this map unit.

This Storden soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer is mildly alkaline or moderately alkaline. The subsoil is very low in available phosphorus and potassium. The surface layer is friable and easily tilled through a fairly wide range in moisture content.

Most areas of this soil are used for grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult because of rolling topography and short slopes, but in places these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce crusting, and maintain good tilth.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks or ornamental plantings. A mulch cover helps to deter erosion. Species adapted to calcareous soils should be selected for plantings.

This Storden soil is in capability subclass IIIe.

62D3—Storden loam, 9 to 14 percent slopes, severely eroded. This strongly sloping, well drained, calcareous soil is on convex side slopes that border streams and upland drainageways. Slopes generally are short. Individual areas range from 2 to 10 acres and are elongated. A few areas, mostly along the major streams, are 25 acres or more.

Typically, the surface layer is dark grayish brown, calcareous, friable loam about 8 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous loam. In places, strata of silt loam and sandy loam are in the substratum.

Included with this soil in mapping are small sandy or gravelly knobs. These areas make up less than 5 percent of the map unit.

This Storden soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is less than 0.5 percent in the surface layer. Typically, the soil is moderately alkaline throughout. Below the surface layer, available phosphorus and potassium generally are very low. It typically is easy to maintain good tilth.

Most areas are cultivated, but some areas are in pasture. If erosion is controlled and fertility is improved, the soil is poorly suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. It has a severe erosion hazard. Conservation tillage, a practice that leaves all or part of the residue on the surface, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult in places because of short, irregular slopes; in most places, however, these practices are suited. Larger additions of phosphorous and potassium fertilizers are needed because of the high lime content of the soil.

Soybeans may also require additions of iron compounds. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce soil erosion and crusting, and increase the infiltration rate. Much of the rainfall from intense rains runs off unless a plant cover is present. Pastures commonly are renovated by planting a cultivated crop one year and reestablishing the pasture the next year. Stands can be maintained for a period of years by controlling grazing and by reseeding in the existing stand and fertilizing as needed.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks or ornamental plantings. A mulch cover helps to deter erosion.

This Storden soil is in capability subclass IVe.

62E—Storden loam, 14 to 18 percent slopes. This moderately steep, well drained, calcareous soil is on convex side slopes that border streams and upland drainageways. Slopes generally are short. Typically, areas are 2 to 10 acres and are elongated. A few areas, mostly along major streams, are 25 acres or more.

Typically, the surface layer is very dark brown, friable loam about 9 inches thick. The subsurface layer is very dark grayish brown and dark yellowish brown, calcareous loam about 8 inches thick. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam. In places, the substratum has strata of silt loam and sandy loam.

Included with this soil in mapping are some areas that have slopes of less than 14 percent or more than 18 percent. These areas make up about 10 percent of the map unit.

This Storden soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. Typically, the soil is moderately alkaline throughout. Below the surface layer, available phosphorus and potassium generally are very low.

Most areas of this soil are in pasture; a few areas are in cultivated crops. The soil is poorly suited to corn and soybeans. It is moderately suited to small grains and grasses and legumes for hay and pasture. The soil has a severe erosion hazard if it is used for cultivated crops or if pastures are overgrazed. Rainfall runs off rapidly, and a plant cover should be maintained. Planting row crops occasionally is suitable if pastures are in need of renovation. Conservation tillage, a practice that leaves all or part of the crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. In places, contouring and terracing are difficult because of steep, short slopes. It typically is easy to maintain good tilth. The use of crop residue or other organic material helps to improve fertility, reduce soil erosion and crusting, and increase the infiltration rate. Pastures commonly are renovated by planting a cultivated crop one year and reestablishing the pasture the next year. Stands can be maintained for a period of years by controlling grazing and by reseeding in the existing stand and fertilizing as needed.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks or ornamental plantings. A mulch cover helps to deter erosion.

This Storden soil is in capability subclass IVe.

62E3—Storden loam, 14 to 18 percent slopes, severely eroded. This moderately steep, well drained soil is on knobs and shoulders of hills. Slopes are short. Individual areas range from 2 to 10 acres and are circular to long and narrow.

Typically, the surface layer is dark grayish brown, calcareous, friable loam about 8 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. The substratum to a depth of about 60 inches is light olive brown, mottled, friable, calcareous loam.

Included with this soil in mapping are small areas on high knobs of Zenor soils that contain more sand and gravel and are more droughty. These areas make up less than 5 percent of this map unit.

This Storden soil is moderately permeable, and surface runoff is very rapid. The available water capacity is high. The content of organic matter is less than 0.5 percent in the surface layer. The soil is mildly alkaline or moderately alkaline and does not need lime; it has excess lime. The subsoil is very low in available phosphorus and potassium. Excess lime in the surface layer affects crop response to fertilizer and herbicides. Soil tilth is generally good; however, surface crusting is a problem after heavy rains.

Most areas of this soil are cultivated. This soil is generally unsuited to cultivated crops. It is better suited to small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of further erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring is difficult because of hilly topography and short slopes, but in most places these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce crusting, and maintain good tilth. Pasture or hay is also effective in controlling erosion.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks or ornamental plantings. Planting may be difficult because of steep slopes. A mulch cover helps to deter erosion. Species adapted to calcareous soils should be selected for plantings.

This Storden soil is in capability subclass VIe.

62F—Storden loam, 18 to 25 percent slopes. This steep, well drained, calcareous soil is on convex side slopes that border streams and upland drainageways. Slopes generally are short. Typical areas are 2 to 10 acres and are elongated. A few areas along major streams are 25 acres or more.

Typically, the surface layer is very dark brown, calcareous loam about 9 inches thick. The subsurface layer is dark grayish brown and dark yellowish brown, calcareous loam about 8 inches thick. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam. In places, the substratum has strata of silt loam and sandy loam.

Included with this soil in mapping are some Storden soils that have slopes of less than 18 percent or more than 25 percent. These inclusions make up about 10 percent of the map unit. Also included are areas where the substratum has stratified lenses of loamy sand and sand. These areas are on similar landscape positions as this Storden soil and make up less than 5 percent of the map unit.

This Storden soil is moderately permeable, and surface runoff is very rapid. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. Typically, the soil is moderately alkaline throughout. Below the surface layer, available phosphorus and potassium generally are very low.

Most areas of this soil are in pasture. The soil is generally unsuited to cultivated crops. It is better suited to grasses and legumes for hay and pasture. This soil has a severe erosion hazard if used for cultivated crops. It is too erodible to be used for unlimited grazing. The use of farm machinery is hazardous because of the steep slope, and some areas remain in native grasses. Where farm machinery can be used, it is practical to fertilize and renovate pastures as needed.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks or ornamental plantings. Planting is difficult because of the steep slopes. A mulch cover helps to deter erosion.

This Storden soil is in capability subclass VIe.

65F—Lindley loam, 18 to 25 percent slopes. This steep, well drained soil is on convex side slopes in uplands. Individual areas range from 5 to 25 acres and are long, narrow, and irregular in shape.

Typically, the surface layer is very dark grayish brown loam about 3 inches thick. The subsurface layer is dark grayish brown and brown loam about 8 inches thick. The subsoil is about 30 inches thick. It is brown, friable clay loam in the upper part; dark yellowish brown, mottled, firm clay loam in the middle part; and yellowish brown, mottled, firm clay loam in the lower part. The substratum to a depth of about 60 inches is light yellowish brown and strong brown, mottled clay loam.

Included with this soil in mapping are a few small areas of severely eroded soils and small areas of red clay on similar landscape positions. These areas make up less than 10 percent of this map unit.

Permeability of this Lindley soil is moderately slow, and surface runoff is very rapid. The available water capacity is high. The content of organic matter is about 0.5 to 1 percent in the surface layer. This soil has moderate shrink-swell potential in the subsoil. Typically, the surface layer is slightly acid to medium acid and the subsoil is medium acid to strongly acid. The subsoil is medium in available phosphorus and very low in available potassium.

Most areas of this soil are in woodland. This soil is generally unsuited to cultivated crops but is moderately suited to pasture and trees. Farm machinery or tree-starting equipment can be used on many areas of this soil, but caution is necessary because of steepness. If trees are cleared, extreme care is needed to prevent the loss by erosion of the few inches of topsoil. This soil has suitable sites for ponds.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks or ornamental plantings. Planting is difficult because of the steep slopes. A mulch cover helps to deter erosion.

This Lindley soil is in capability subclass VIIe.

90—Okoboji mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions. Most individual areas are in the middle of large depressions. This soil is subject to ponding. Typical areas are from 5 to 20 acres and are irregular, but some areas are 40 acres or more.

Typically, the surface layer is black, mucky silt loam about 8 inches thick. The subsurface layer is black, mucky silt loam and silty clay loam about 25 inches thick. The subsoil is gray, mottled, friable silty clay loam about 7 inches thick. The substratum to a depth of about 60 inches is gray and dark gray, mottled silt loam and silty clay loam. In places, the surface layer is muck about 10 to 15 inches thick.

Included with this soil in mapping are small areas of calcareous Harps soils. These areas make up about 5 percent of the map unit and are on knolls and rims of depressions.

Permeability of this Okoboji soil is moderately slow, and surface runoff from adjacent soils is slow to ponded. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 9 to 18 percent in the surface layer. This soil has high shrink-swell potential. Typically, the mucky surface layer is strongly acid or medium acid, and the subsurface layer and subsoil are neutral or mildly alkaline. The subsoil generally is very low in available phosphorus and potassium. It typically is easy to maintain good tilth if proper drainage measures have been taken.

Most areas of this soil are cultivated. If adequately drained, the soil is moderately suited to corn, soybeans, small grains, and grasses. Surface intakes remove excess ponded water. Tile drains remove excess subsurface water. Deep cuts commonly are needed to obtain outlets. The use of crop residue or other organic material helps to reduce wind erosion.

Wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Species that withstand wet conditions are needed. Artificial drainage is beneficial to establish trees and shrubs.

This Okoboji soil is in capability subclass IIIw.

95—Harps loam, 1 to 3 percent slopes. This very gently sloping, poorly drained, calcareous soil is on plane or slightly convex positions, typically on rims of larger upland depressions. Typical areas are 2 to 10 acres and elliptical.

Typically, the surface layer is black, calcareous loam about 8 inches thick. The subsurface layer is very dark gray, calcareous clay loam about 12 inches thick. The subsoil is olive gray and light olive gray, mottled, calcareous, friable loam about 21 inches thick. The substratum to a depth of about 60 inches is light olive gray, mottled, calcareous loam. In places, the subsoil has thin lenses of sandy loam.

Included with this soil in mapping are small areas of highly calcareous sandy spots. Also included are areas where the substratum is stratified with lenses of loamy sand and sand. These inclusions, which make up about 5 percent of the map unit, are on landscape positions similar to this Harps soil.

This Harps soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. The soil is moderately alkaline throughout. The subsoil generally is very low in available phosphorus and potassium. The surface layer typically needs special care to maintain good tilth.

Most areas are cultivated. If adequately drained, the soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Tile drains remove excess subsurface water. Cultivating this soil when it is too wet causes compaction and cloddiness. Conservation tillage, which leaves residue on the surface, reduces runoff and increases infiltration. Returning crop residue or regularly adding other organic material helps to reduce wind erosion and crusting and increase the infiltration rate. Excess lime modifies crop response to fertilizer and herbicides. Iron chlorosis and herbicide carry-over damage are common in soybeans on this soil. Proper selection and use of soybean varieties, herbicides, and fertilizers minimize these problems.

A high water table and excess lime are the main limitations if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. Species that withstand wet, calcareous soils should be selected.

This Harps soil is in capability subclass IIw.

107—Webster clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on slightly convex to slightly concave positions on uplands. Typically, it is in swales. Most individual areas are about 5 to 15 acres and are elongated, but some areas are as large as 100 acres and are irregular in shape.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer, about 9 inches thick, is black clay loam in the upper part and very dark gray clay loam in the lower part. The subsoil is mottled, friable clay loam about 21 inches thick. The upper part is very dark gray, and the lower part is olive gray. The substratum to a depth of about 60 inches is olive gray, mottled loam and sandy loam. In places, the surface layer is silty clay loam.

Included with this soil in mapping are some small areas of the depressional, very poorly drained Okoboji soils and the calcareous Harps soils, which are on landscape positions similar to this Webster soil. These areas make up about 10 percent of the map unit.

This Webster soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. Typically, the surface layer is neutral, and the subsoil is mildly alkaline. The subsoil generally is very low in available phosphorus and potassium.

Most areas are cultivated. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture if adequately drained. Tile drains are effective in removing excess water. Cultivating this soil when it is too wet causes compaction and cloddiness.

Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent soil loss. Returning crop residue or regularly adding other organic material helps to reduce wind erosion and crusting and increase the infiltration rate.

Wetness is the main limitation if this soil is used for trees and shrubs for windbreaks and ornamental plantings. Selecting species that withstand wetness and providing adequate drainage are important.

This Webster soil is in capability subclass IIw.

108—Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, well drained soil is on slightly convex slopes. It dominantly is on terraces, but a few areas are on uplands. Typical areas on terraces are 5 to 20 acres and irregular in shape. Typical areas on uplands are 2 to 3 acres and irregular in shape.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is dark brown loam about 5 inches thick. The subsoil is about 13 inches thick. The upper part is dark yellowish brown, friable loam, and the lower part is brown, very friable sandy loam. The substratum to a depth of about 60 inches is strong brown and dark yellowish brown sand and loamy sand. In places, the loamy sand or sand and gravel is at a depth as shallow as 18 inches. In other places, the lower part of the subsoil is sandy loam or sandy clay loam. Also in places, the sand and gravel is at a depth of 32 to 40 inches.

Included with this soil in mapping are some sandy and gravelly soils on small knobs and some small areas of poorly drained soils on low lying positions. These inclusions make up less than 10 percent of the map unit.

This Wadena soil is moderately permeable in the solum and rapidly permeable in the substratum. Surface runoff is slow. The available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. Typically, the surface layer, subsurface layer, and upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas are cultivated. The soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. It is seasonally droughty because of the sandy and gravelly substratum. Conservation tillage, a practice that leaves all or part of the residue on the surface, helps to prevent erosion. Returning crop residue or regularly adding other organic material helps to improve fertility, conserve moisture, and reduce soil blowing. Overgrazing reduces the protective plant cover and can result in increased soil blowing.

Seasonal droughtiness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Species that withstand droughtiness should be selected, or supplemental irrigation can be used where practical.

This Wadena soil is in capability subclass IIs.

108B—Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex slopes. Most areas of this soil are on terraces. Typically, areas are 2 to 10 acres and are irregular in shape.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is dark brown loam about 5 inches thick. The subsoil is about 13 inches thick. The upper part is dark yellowish brown, friable loam, and the lower part is brown, very friable sandy loam. The substratum to a depth of about 60 inches is strong brown loamy sand and yellowish brown sand. In places, depth to sand and gravel is 32 to 40 inches.

Included with this soil in mapping on convex knobs are some small areas of droughty Estherville soils. These inclusions make up about 5 percent of the map unit.

This Wadena soil is moderately permeable in the surface layer, subsurface layer, and subsoil and rapidly permeable in the substratum. Surface runoff is medium. The available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. Typically, the surface layer, subsurface layer, and upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas of this soil are cultivated. The soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. This soil is seasonally droughty because of the sandy and gravelly substratum. Conservation tillage, a practice that leaves all or part of the crop residue on the surface throughout the year, helps to prevent excessive soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility, conserve moisture, and reduce soil erosion. Overgrazing of pastures reduces the protective plant cover and results in increased runoff and erosion.

This soil has a slight erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings, and it is seasonally droughty. A mulch cover helps to reduce erosion and conserve moisture. Species that withstand droughtiness should be selected, or supplemental irrigation can be used where practical.

This Wadena soil is in capability subclass IIe.

135—Coland clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom lands. It is subject to flooding. Typically, individual areas are 10 to 50 acres and are elongated.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is clay loam about 39 inches thick. It is black in the upper part and very dark gray and mottled in the lower part. The substratum to a depth of about 60 inches is olive gray clay loam.

Included with this soil in mapping are small areas of Talcot soils, which are underlain by sand and gravel and are calcareous. These areas make up less than 10 percent of this map unit.

This Coland soil is moderately permeable, and surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer. This soil has high shrink-swell potential. Typically, the surface layer and subsurface layer are neutral, but, in places, it is mildly alkaline throughout. Below the surface layer, available phosphorus is low, and available potassium generally is very low.

Most areas of this soil are cultivated. Some areas that are not protected from flooding or that are isolated by a meandering stream are used for pasture. If adequate drainage can be provided and flooding is controlled, the soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth. Cultivating this soil when it is too wet causes compaction and cloddiness. Grasses and legumes that are tolerant of wetness produce the best pastures. Weed control is important because of weed seeds carried in by flood waters.

A high water table and flooding are the main limitations if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. It is important to select species that withstand wetness and flooding.

This Coland soil is in capability subclass IIw.

136B—Ankeny fine sandy loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on slightly concave foot slopes and on convex alluvial fans on uplands. Individual areas range from 2 to 10 acres and are long and narrow.

Typically, the surface layer is very dark brown fine sandy loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown, friable fine sandy loam about 28 inches thick. The subsoil is about 18 inches thick. The upper part is brown, very friable fine sandy loam, and the lower part is brown, very friable loamy fine sand. The substratum to a depth of about 60 inches is dark yellowish brown loamy fine sand grading with depth to yellowish brown fine sand. In places, this map unit contains small areas of this soil on steeper slopes.

Permeability of this Ankeny soil is moderately rapid, and surface runoff is medium. The available water capacity is moderate. The content of organic matter is about 2 to 3 percent in the surface layer. The surface layer is slightly acid or neutral depending on past liming practices, and the subsoil is neutral or slightly acid. The subsoil is very low in available phosphorus and potassium. This soil has good tilth.

Most areas of this soil are cultivated. Areas that are not cultivated are generally long, narrow strips between very steep soils and major watercourses. These areas are small and are generally managed with the steeper soils. This soil is only moderately suited to row crops because of limited available water capacity. Some areas of the more sloping soils, especially those on foot slopes, are subject to erosion and to rilling if this soil is not protected by a cover of plants. If this soil is used for cultivated crops, conservation tillage, a practice that leaves crop residue on the surface throughout the year, terraces, winter cover crops, and grassed waterways help to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility.

This soil has a slight erosion hazard if it is used for trees and shrubs as windbreaks and ornamental plantings. A mulch cover helps to reduce erosion.

This Ankeny soil is in capability subclass IIe.

138B—Clarion loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex knolls on uplands. Typical areas are 2 to 10 acres and are oblong or elongated, but a few individual areas are more than 50 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is friable loam about 20 inches thick. It is brown in the upper and middle parts and yellowish brown in the lower part. The substratum to a depth of about 60 inches is light olive brown, mottled loam. In places, lenses of silt loam, loamy sand, or sand are in the substratum.

Included with this soil in mapping are areas of somewhat poorly drained Nicollet soils. They are at lower elevations than this Clarion soil. Also included are some small sandy or gravelly knobs and some Storden soils, which are at higher elevations than this Clarion soil. These areas make up about 10 percent of this map unit.

This Clarion soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. Typically, the surface layer and upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas are cultivated. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If it is used for cultivated crops, there is a hazard of erosion. Conservation tillage, a practice that leaves all or part of the crop residue on the surface, and grassed waterways help to prevent excessive soil loss. In places, contouring and terracing are difficult because of undulating topography and short slopes; in most places, however, these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce soil erosion and crusting, and increase infiltration.

This soil has a slight erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion.

This Clarion soil is in capability subclass IIe.

138C—Clarion loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on knolls on uplands and on convex side slopes that border streams and upland drainageways. Slopes generally are short. Typical areas are 2 to 10 acres and are irregular in shape or elongated. Some individual areas near streams are somewhat larger and are irregular in shape.

Typically, the surface layer is very dark gray loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 4 inches thick. The subsoil is friable loam about 16 inches thick. It is brown in the upper part and dark yellowish brown and yellowish brown in the middle and lower parts. The substratum to a depth of about 60 inches is light olive brown, mottled loam. In places, concave positions near the base of the slope have a dark surface layer as much as 24 to 30 inches thick.

Included with this soil in mapping are some small sandy or gravelly knobs and areas of Storden soils, which are at higher elevations than this Clarion soil. These inclusions make up less than 10 percent of the map unit.

This Clarion soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 3 to 3.5 percent in the surface layer. Typically, the surface layer, subsurface layer, and upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas are not cultivated but are used for pasture. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, a practice that leaves all or part of the crop residue on the surface, and grassed waterways help to prevent excessive soil loss. In places, contouring and terracing are difficult because of undulating topography and short slopes; in most places, however, these practices are practical. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce soil erosion and crusting, and increase infiltration.

This soil has a moderate erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion.

This Clarion soil is in capability subclass IIIe.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on knolls on uplands and on convex side slopes that border upland drainageways. Slopes typically are short. Individual areas range from 5 to 35 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is friable loam about 20 inches thick. The upper and middle parts are dark brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is yellowish brown and light olive brown, mottled loam.

Included with this soil in mapping are some small areas of calcareous Storden soil, which are mainly on the steepest parts of slopes. They make up about 5 percent of the map unit.

This Clarion soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. Typically, the surface layer and upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas of this soil are cultivated. The soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay or pasture. If the soil is used for cultivated crops, there is a hazard of further erosion damage. Conservation tillage, a practice that leaves all or part of the crop residue on the surface throughout the year, is effective in helping to prevent excessive soil loss. Grassed waterways help to prevent gully erosion (fig. 11).

The use of the soil for pasture or hay is effective in controlling erosion. Overgrazing, however, causes surface compaction and a poor stand and results in increased runoff.

This soil has a moderate erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps deter erosion.

This Clarion soil is in capability subclass IIIe.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on convex, upland side slopes that border streams and upland drainageways. Slopes generally are short. Typically, areas are 2 to 10 acres and are elongated. A few areas are larger.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is friable loam about 14 inches thick. It is brown in the upper part and dark yellowish brown and yellowish brown in the middle and lower parts. The substratum to a depth of about 60 inches is light olive brown loam. In places, the surface layer is thicker and darker. In other places, lenses of loamy sand or sand are in the substratum.

This Clarion soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. Typically, the surface layer and upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium. It typically is easy to maintain good tilth.

Some areas are cultivated; other areas are in pasture. The soil is moderately suited to corn and soybeans; it is well suited to small grains and grasses and legumes for hay and pasture. This soil has a severe erosion hazard if it is used for cultivated crops. Conservation tillage, a practice that leaves all or part of the crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. In places, contouring and terracing are difficult because of short slopes; in most places, however, these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce soil erosion and crusting, and increase infiltration. Farm machinery can be used on this soil to renovate pasture as needed.

Figure 11.—Grassed waterways help to prevent soil erosion on sloping Clarion soils.

Overgrazing results in a poor plant cover and increased runoff.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion.

This soil is in capability subclass IIIe.

168B—Hayden loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex, upland ridgetops. Slopes typically are short. Individual areas range from 2 to 20 acres and are irregular and narrow.

Typically, the surface layer is very dark grayish brown loam about 3 inches thick. The subsurface layer is dark grayish brown loam about 5 inches thick. The subsoil is about 45 inches thick. The upper part is brown, friable loam; the middle part is dark yellowish brown and yellowish brown, friable clay loam; and the lower part is light olive brown, friable clay loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam.

Included with this soil in mapping are small areas of poorly drained Cordova soils on low lying positions and small areas of other very poorly drained soils that pond water in depressions. These areas make up less than 7 percent of this map unit.

This Hayden soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 1.5 to 2.5 percent in the surface layer. The surface layer is slightly acid or neutral. The subsoil is medium in available phosphorus and very low in available potassium. The surface layer is friable and easily tilled; however, it has a tendency to crust or puddle after hard rains.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. Contouring and terracing are difficult because of irregular shapes and short slopes, but in some places these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth.

This soil is well suited to trees for windbreaks and woodland areas. Many small areas remain in native hardwoods. No particular problems should be encountered in planting new stands of trees if species are selected and managed properly.

This Hayden soil is in capability subclass IIe.

168C—Hayden loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on convex, upland ridgetops. Slopes typically are short. Individual areas range from 2 to 50 acres and are irregular in shape and narrow.

Typically, the surface layer is very dark grayish brown loam about 3 inches thick. The subsurface layer is dark grayish brown loam about 5 inches thick. The subsoil is about 45 inches thick. The upper part is brown, friable loam; and the middle and lower parts are dark yellowish brown and yellowish brown, friable loam and clay loam. The substratum to a depth of about 60 inches is yellowish brown, mottled loam. In places, the surface layer is lighter colored, and the subsoil is lighter textured.

This Hayden soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer is slightly acid or neutral. The subsoil is medium in available phosphorus and very low in available potassium. The surface layer is friable and easily tilled; however, it has a tendency to crust or puddle after hard rains.

Most areas of this soil are in timber or pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. Contouring and terracing are difficult because of irregular shapes and short slopes, but in many places these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth.

This soil is moderately suited to trees for windbreaks and woodland areas. Many small areas remain in native hardwoods. No particular problems should be encountered in planting new stands of trees if species are selected and managed properly.

This Hayden soil is in capability subclass IIIe.

168E—Hayden loam, 9 to 18 percent slopes. This strongly sloping and moderately steep, well drained soil is on upland side slopes adjacent to major streams. Most areas are dissected by deep drainageways. Individual areas range from 10 to 40 acres and are irregular in shape.

Typically, the surface layer is very dark gray loam about 2 inches thick. The subsurface layer is brown, friable loam about 6 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is brown, and the lower part is yellowish brown. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam. In places, this soil has a thicker, dark surface layer.

Included with this soil in mapping on similar landscape positions are small areas of gravelly outwash material that has lower available water capacity. These areas make up less than 8 percent of this map unit.

This Hayden soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is about 1 to 1.5 percent in the surface layer. The surface layer is slightly acid or neutral. The subsoil is medium in available phosphorus and very low in available potassium.

Because of the strongly sloping and moderately steep slopes, this soil is poorly suited to cultivated crops. It is well suited to trees, hay, and pasture. Many areas remain in native hardwoods. Careful consideration should be given to the location of trails and roads to reduce the possibility of erosion. The slope of this soil is steep enough to cause some hazard in the operation of equipment. Survival of seedlings or competition from undesirable plants should not be a problem.

This Hayden soil is in capability subclass IVe.

168F—Hayden loam, 18 to 25 percent slopes. This steep, well drained soil is on upland side slopes adjacent to major streams. Most areas are dissected by deep drainageways. Individual areas range from 10 to 70 acres and are irregular.

Typically, the surface layer is very dark gray loam about 2 inches thick. The subsurface layer is brown loam about 6 inches thick. The subsoil is friable clay loam about 24 inches thick. The upper part is brown, and the lower part is yellowish brown. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam. Some areas have a thicker, dark surface layer.

Included with this soil in mapping on similar landscape positions are small areas of gravelly outwash material that has a lower available water capacity. These areas make up less than 8 percent of this map unit.

This Hayden soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is about 1 to 1.5 percent in the surface layer. The surface layer is slightly acid or neutral. The subsoil is medium in available phosphorus and very low in available potassium.

Because of the steep slopes, this soil is not suited to cultivated crops and is moderately suited to pastures and trees. Many areas remain in native hardwoods; better quality woodland can be obtained by restricted grazing. Careful consideration should be given to the location of trails and roads to reduce the possibility of erosion. The slope of this soil is steep enough to cause some hazard in the operation of equipment. Survival of seedlings or competition from undesirable plants should not be a problem.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion.

This Hayden soil is in capability subclass VIe.

175—Dickinson fine sandy loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is on slightly convex areas on stream terraces and uplands. Individual areas range from 2 to 5 acres and are irregular in shape.

Typically, the surface layer is very dark brown fine sandy loam about 8 inches thick. The subsurface layer is very dark brown fine sandy loam about 9 inches thick. The subsoil is about 23 inches thick. The upper part is very dark grayish brown, very friable fine sandy loam; the middle part is brown, very friable fine sandy loam; and the lower part is dark yellowish brown, friable loamy fine sand. The substratum to a depth of about 60 inches is yellowish brown sand. In places, the subsoil has more sand and less clay.

Included with this soil in mapping on similar landscape positions are a few small, wet, seepy areas that need tile drainage. These areas make up about 5 percent of this map unit.

This Dickinson soil has slow surface runoff and low available water capacity. Permeability is moderately rapid in the upper part and rapid in the lower part. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer generally is acid if not limed during the past 5 years. The subsoil is very low in available phosphorus and potassium. Soil tilth is good.

Most areas of this soil are cultivated. This soil is moderately suited to cultivated crops, hay, and pasture. It is droughty in some years. It is subject to slight soil blowing if cultivated. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and winter cover crops help to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility. Cultivation after heavy rains helps to prevent damage to small row crops from blowing sand. Pasture and hay are also effective in controlling erosion.

This soil is well suited to trees for windbreaks and woodlands. Seedling mortality is high because of droughtiness. Seedlings should be spaced closer together when planted and thinned later to achieve the desired stand density.

This Dickinson soil is in capability subclass IIIs.

175B—Dickinson fine sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on convex mounds and dunes on stream terraces and uplands. Individual areas range from 2 to 25 acres and are irregular in shape.

Typically, the surface layer is very dark brown fine sandy loam about 8 inches thick. The subsurface layer is very dark brown fine sandy loam about 9 inches thick. The subsoil is about 23 inches thick. The upper part is very dark grayish brown, friable fine sandy loam; the middle part is brown, very friable fine sandy loam; and the lower part is dark yellowish brown, very friable loamy fine sand. The substratum to a depth of about 60 inches is yellowish brown sand.

Included with this soil in mapping on similar landscape positions are a few small, side hill seep areas that need tile drainage. These areas make up about 5 percent of this map unit.

This Dickinson soil has medium surface runoff. The available water capacity is low. Permeability is moderately rapid in the upper part and rapid in the lower part. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer is generally acid if not limed. The subsoil is very low in available phosphorus and potassium. Soil tilth is good.

Most areas of this soil are cultivated. This soil is moderately suited to cultivated crops, hay, and pasture. It is subject to soil blowing if used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and winter cover crops help to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility. Cultivation after heavy rains helps to prevent damage to small row crops from blowing sand. Pasture and hay are also effective in controlling erosion.

This soil is well suited to trees for windbreaks and woodland. Seedling mortality is high because of droughtiness. Seedlings should be spaced closer together when planted and thinned later to achieve the desired stand density.

This Dickinson soil is in capability subclass IIIe.

175C—Dickinson fine sandy loam, 5 to 9 percent slopes. This moderately sloping, somewhat excessively drained soil is on convex side slopes of uplands along streams. Individual areas range from 4 to 20 acres and are long and narrow.

Typically, the surface layer is very dark brown fine sandy loam about 8 inches thick. The subsurface layer is very dark brown fine sandy loam about 4 inches thick. The subsoil is about 23 inches thick. The upper part is very dark grayish brown, very friable sandy loam; the middle part is brown, very friable fine sandy loam; and the lower part is dark yellowish brown, very friable loamy fine sand. The substratum to a depth of about 60 inches is yellowish brown sand. In some places, glacial till is at a depth of 40 inches. Other places have sand throughout.

Included with this soil in mapping on similar landscape positions are a few small areas of Zenor soils that have some coarse sand and gravel throughout and Clarion soils that have more clay throughout. These areas make up about 10 percent of this map unit.

This Dickinson soil has medium surface runoff. The available water capacity is low. Permeability is moderately rapid in the upper part and rapid in the lower part. The content of organic matter is about 1 to 1.5 percent in the surface layer. The surface layer is slightly acid to neutral. The subsoil is very low in available phosphorus and potassium. The surface layer is very friable and easily tilled through a wide range in moisture content.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. When used for cultivated crops, erosion and soil blowing are hazards. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Returning crop residue also helps to maintain good tilth, conserve moisture, and increase water infiltration. This soil is droughty in years of below normal rainfall or during extended dry periods. The selection of herbicides and their application rate is affected by the sand content of this soil.

When used for pastureland, overgrazing or grazing when the soil is too wet causes surface compaction and increases runoff. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture and soil in good condition.

This soil is well suited to trees for windbreaks and woodlands. Seedling mortality is high because of droughtiness. Seedlings should be spaced closer together when planted and thinned later to achieve the desired stand density.

This Dickinson soil is in capability subclass IIIe.

201B—Coland-Terril complex, 1 to 5 percent slopes. These very gently sloping and gently sloping soils are in long narrow valleys. The stream channel within this map unit meanders from valley side to valley side. The poorly drained Coland soil is on flood plains and is subject to flooding. The moderately well drained Terril soil is on foot slopes and alluvial fans that receive runoff from adjacent upland soils. Individual areas range from 2 to 10 acres and are long and narrow. This map unit contains 65 percent Coland soils and 35 percent Terril soils. The soils are so intricately mixed, or areas are so small in size that it was not practical to separate them in mapping.

Typically, the surface layer of the Coland soil is black clay loam about 8 inches thick. The subsurface layer is clay loam about 39 inches thick. It is black in the upper part and very dark gray and mottled in the lower part. The substratum to a depth of about 60 inches is olive gray clay loam.

Typically, the surface layer of the Terril soil is very dark brown loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown loam about 24 inches thick. The subsoil extends to a depth of about 60 inches. It is dark brown, friable loam in the upper part and brown, friable clay loam in the lower part.

Coland and Terril soils are moderately permeable, and surface runoff is slow. The Coland soil has a seasonal high water table. The available water capacity is high in both soils. The content of organic matter in the surface layer is 4 to 5 percent in Terril soils and about 5 to 7 percent in Coland soils. The Coland soil has high shrink-swell potential. The surface layer and subsurface layer in both soils typically are slightly acid or neutral. The subsoil in both soils generally is very low in available phosphorus and potassium.

Most areas of this complex are in pasture or woodland. These soils are poorly suited to corn, soybeans, and small grains. A meandering stream dissects these areas, and it is impractical to use farm machinery in places. The areas are well suited to wildlife habitat.

A high water table and flooding are the main limitations if this complex is used for trees and shrubs. Species selected for wildlife or woodland plantings must be able to withstand wet soil conditions.

The Coland and Terril soils in this complex are in capability subclass Vw.

202—Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on stream terraces and upland outwash areas. Slopes typically are nearly level or convex, but in places they are slightly concave. Individual areas range from 2 to 10 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil, about 14 inches thick, is dark grayish brown, mottled, friable loam and sandy clay loam. The substratum to a depth of about 60 inches is light olive brown and yellowish brown sand and gravel. In places, the substratum is loamy sand or sand that has less than 5 percent gravel. In other places, loamy soil material is below the sand and gravel at a depth of 40 to 60 inches.

This Cylinder soil is moderately permeable in the surface layer and upper part of the subsoil and very rapidly permeable below that depth. Surface runoff is slow. The soil has a seasonal high water table. The available water capacity is low or moderate. The content of organic matter is about 4 to 5 percent in the surface layer. Typically, the surface layer and upper part of the subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium. It typically is easy to maintain good tilth.

Most areas are cultivated. The soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. This soil has a high water table during wet seasons but becomes droughty after brief dry periods. Returning crop residue or regularly adding other organic material helps to improve fertility, conserve moisture, and reduce soil blowing.

This soil has a drought hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. Mulch cover helps to conserve moisture. Generally, plantings on these sites must be able to withstand seasonal wetness as well as droughtiness. Installing a drainage system and using supplemental irrigation as needed would make it possible to use almost any species adapted to the climate of the county.

This Cylinder soil is in capability subclass IIs.

203—Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on stream terraces and upland outwash areas. Slopes typically are nearly level or concave, but in places they are slightly convex.

Individual areas range from 2 to 15 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark grayish brown loam about 11 inches thick. The subsoil is dark grayish brown and brown, mottled, friable loam about 23 inches thick. The substratum to a depth of about 60 inches is dark yellowish brown and grayish brown sand and gravel. In places, the substratum is loamy sand or sand that has less than 5 percent gravel. In other places, loamy soil material is below the sand and gravel at a depth of 50 to 60 inches.

This Cylinder soil is moderately permeable in the solum and very rapidly permeable in the substratum. Surface runoff is slow. The soil has a seasonal high water table. The available water capacity is moderate. The content of organic matter is about 4 to 5 percent in the surface layer. Typically, the surface layer and subsoil are slightly acid or neutral. The subsoil generally is very low in available phosphorus and potassium.

Most areas of this soil are cultivated. The soil is well suited to corn, soybeans, and small grains and to legumes for hay and pasture. This soil has a high water table during wet seasons but becomes droughty after brief dry periods. Returning crop residue or regularly adding other organic material helps to improve fertility, conserve moisture, and reduce soil blowing.

This soil has a drought hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to conserve moisture. Generally, plantings on these sites must be able to withstand seasonal wetness as well as droughtiness. Installing a drainage system and using supplemental irrigation as needed would make it possible to use almost any species adapted to the climate of the county.

This Cylinder soil is in capability class I.

221—Palms muck, 0 to 1 percent slopes. This level, very poorly drained soil is in depressions of uplands. Individual areas range from 2 to 12 acres and are circular. This soil ponds after heavy rains.

Typically, the surface layer is black sapric material about 7 inches thick. The subsurface layer is black sapric material about 19 inches thick. The substratum to a depth of about 60 inches is dark grayish brown, very dark grayish brown, light olive brown, and gray, mottled silt loam.

Included with this soil in mapping on similar landscape positions are soils with organic layers to a depth of more than 51 inches. Tile lines can settle and may be difficult to maintain in these areas. These areas make up about 15 percent of this map unit.

Permeability of this Palms soil is moderately rapid in the organic layers and moderate in the substratum. The soil has a seasonal high water table. The available water capacity is very high. The content of organic matter is greater than 20 percent in the surface layer. The soil is neutral to moderately alkaline and does not need lime. The subsoil is very low in available phosphorus and potassium. This soil is ponded after heavy rains and spring thaws even if it is drained. Tilth is good when the soil is adequately drained. Calcareous areas affect the response of herbicides and fertilizer.

This soil is moderately suited to corn, soybeans, specialty crops, and grasses for hay and pasture where it is properly tile drained. Undrained areas are well suited to wildlife habitat. Small grains have a lodging problem on this soil. Legumes commonly experience winter kill or drown. If this soil is used for cultivated crops, there is a hazard of wind erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, winter cover crops, and shelterbelts help to prevent excessive soil loss. There is danger of early frost in the fall. Over a length of time, subsidence occurs. This should be considered in determining the depth of the tile.

Wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Adequate drainage and the selection of species that can withstand wetness are very important.

This Palms soil is in capability subclass IIIw.

236B—Lester loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on uplands on convex knolls and convex side slopes that border streams and drainageways. Typically, areas are 2 to 5 acres and are irregular in shape. A few individual areas are larger than 20 acres.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. The subsurface layer is dark grayish brown loam about 3 inches thick. The subsoil is brown and dark yellowish brown, friable clay loam about 44 inches thick. The substratum to a depth of about 60 inches is light olive brown loam. In places, the substratum is clay loam and, in places, it has thin lenses of sandy loam.

Included with this soil in mapping are some areas of nearly level, somewhat poorly drained soils. These areas make up about 5 percent of the map unit.

This Lester soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 2.5 to 3.5 percent in the surface layer. Typically, the surface layer, subsurface layer, and subsoil are medium acid or slightly acid. The subsoil generally is medium in available phosphorus and very low in available potassium. It typically is easy to maintain good tilth.

Some areas are in woodland pasture; other areas are cultivated. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, a practice that leaves all or part of the crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. In places, contouring and terracing are difficult because of undulating topography and short slopes; in most places, however, these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce soil erosion and crusting, and increase the infiltration rate.

The soil is well suited to pasture or to trees. Most areas that are used for pasture have scattered trees; some areas have thick stands of trees. Generally, better quality pasture can be obtained by removing the trees. Better quality woodland can be obtained by restricting grazing.

This soil has a slight erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion. Better quality native trees can be left where desired.

This Lester soil is in capability subclass IIe.

236C—Lester loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on knolls and convex side slopes that border streams and upland drainageways. Slopes typically are short. Individual areas range from 2 to 30 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. The subsurface layer is dark grayish brown loam about 3 inches thick. The subsoil is about 44 inches thick. The upper part is brown, friable loam, and the middle and lower parts are dark yellowish brown, friable clay loam. The substratum to a depth of about 60 inches is light olive brown loam.

Included with this soil in mapping are small areas of Okoboji, Webster, and Cordova soils in depressions and swales that need tile drainage. Also included are small areas of Zenor soils on high knobs that are droughty. These areas make up about 10 percent of this map unit.

This Lester soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. The soil generally is acid if not limed in the past 5 years. The subsoil is medium in available phosphorus and very low in available potassium.

Most areas of this soil are in pasture and trees. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult because of undulating topography and short slopes, but in many places these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth.

The use of this soil for pasture or hay is also effective in controlling erosion. This soil is well suited to pasture or to trees. Most areas used for pasture have scattered trees, and some areas have thick stands of trees. Generally, better quality pasture can be obtained by removing the trees. Better quality woodland can be obtained by restricted grazing.

This soil has a moderate erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps deter erosion. Better quality native trees can be left where desired.

This Lester soil is in capability subclass IIIe.

236C2—Lester loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on knolls and on convex side slopes that border streams and upland drainageways. Slopes typically are short. Individual areas range from 2 to 25 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. It is mixed with streaks and pockets of dark brown subsoil material. The subsoil is about 27 inches thick. It is dark yellowish brown and brown, friable loam and clay loam. The substratum to a depth of about 60 inches is light olive brown loam.

Included with this soil in mapping are small areas of calcareous Storden soils on steeper, convex slopes that are severely eroded. These areas affect crop response to fertilizer and herbicides. Also included are small areas of Zenor soils on high knobs that are droughty and small areas of Okoboji, Cordova, and Webster soils in swales and depressions that need tile drainage. These areas make up about 15 percent of this map unit.

This Lester soil is moderately permeable, and surface runoff is medium. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer generally is acid if not limed in the past 5 years. The subsoil is medium in available phosphorus and very low in available potassium.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If this soil is used for cultivated crops, there is a hazard of further erosion. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult because of undulating topography and short slopes, but in many places these practices are suited. Returning crop residue or regularly adding organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is also effective in controlling erosion. This soil is well suited to pasture or trees. Most areas used for pasture have scattered trees, and some areas have thick stands of trees. Generally, better quality pasture can be obtained by removing the trees. Better quality woodland can be obtained by restricted grazing.

This soil has a moderate erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion. Better quality native trees can be left where desired.

This Lester soil is in capability subclass IIIe.

236D—Lester loam, 9 to 14 percent slopes. This strongly sloping, well drained soil is on convex side slopes bordering stream valleys and upland drainageways. Slopes typically are short. Individual areas range from 2 to 5 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. The subsurface layer is dark grayish brown loam about 2 inches thick. The subsoil is about 25 inches thick. It is dark yellowish brown and brown, friable loam and clay loam. The substratum to a depth of about 60 inches is light olive brown and yellowish brown loam.

Included with this soil in mapping are small areas of calcareous Storden soils on steeper, convex side slopes. Also included are small areas of droughty Zenor soils on high knobs. These areas make up about 10 percent of this map unit.

This Lester soil is moderately permeable. Surface runoff is rapid. The available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. The surface layer generally is acid if not limed within the past 5 years. The subsoil is medium in available phosphorus and very low in available potassium.

Most areas of this soil are in pasture or timbered pasture. Typically, these areas have not been cultivated because of associated soils with steep slopes and adjacent, uncrossable waterways. This soil is moderately suited to pasture and trees. Areas that are large enough to be cultivated are moderately suited to corn, soybeans, and small grains.

If this soil is used for trees and shrubs grown as windbreaks and ornamental plantings, the hazard of erosion is moderate. A mulch cover helps to deter erosion. Better quality native trees can be left where desirable.

This Lester soil is in capability subclass IIIe.

236D2—Lester loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on convex side slopes bordering stream valleys and upland drainageways. Slopes typically are short. Individual areas range from 2 to 10 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown and dark brown loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is dark yellowish brown and brown, friable loam and clay loam about 20 inches thick. The substratum to a depth of about 60 inches is light olive brown and yellowish brown loam.

Included with this soil in mapping are small areas of calcareous Storden soils on steeper, convex slopes that are severely eroded. These areas affect crop response to fertilizer and herbicides. Also included are small areas of Zenor soils on high knobs that are droughty. These areas make up about 15 percent of this map unit.

This Lester soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is about 0.5 to 1.5 percent in the surface layer. The surface layer generally is acid if not limed in the past 5 years. The subsoil is medium in available phosphorus and very low in available potassium. Soil tilth is generally good.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains. If this soil is used for cultivated crops, there is a hazard of erosion damage. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult because of undulating topography and short slopes, but in some places these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce crusting, and increase water infiltration.

The use of this soil for pasture or hay is also effective in controlling erosion. This soil is moderately suited to pasture and trees. There is a moderate erosion hazard if the soil is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion. Better quality native trees can be left where desirable.

This Lester soil is in capability subclass IIIe.

236E—Lester loam, 14 to 18 percent slopes. This moderately steep, well drained soil is on convex side slopes bordering stream valleys and upland drainageways and in hilly areas in other parts of the county. Slopes typically are short. Individual areas range from 5 to 10 acres and are irregular in shape.

Typically, the surface layer is very dark grayish brown loam about 7 inches thick. The subsoil is dark yellowish brown, friable loam about 20 inches thick. The substratum to a depth of 60 inches is light olive brown and yellowish brown loam.

Included with this soil in mapping are small areas of Storden soils on similar landscape positions that are calcareous at the surface. Also included are small areas of Zenor soils on high knobs that are droughty. These areas make up about 15 percent of this map unit.

This Lester soil is moderately permeable, and surface runoff is rapid. The available water capacity is high. The content of organic matter is 1 to 2 percent in the surface layer. The surface layer generally is acid if not limed in the past 5 years. The subsoil is medium in available phosphorus and very low in available potassium.

Most areas of this soil are in pasture or timbered pasture. This soil is poorly suited to corn, soybeans, and small grains and is moderately suited to grasses and legumes for hay and pasture and to trees. If this soil is used for cultivated crops, there is a severe hazard of erosion.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion. Better quality native trees can be left where desirable.

This Lester soil is in capability subclass IVe.

236F—Lester loam, 18 to 25 percent slopes. This steep, well drained soil is on upland escarpments adjacent to streams. It is below areas of less sloping Lester soils. Individual areas range from 5 to 50 acres and are irregular in shape.

Typically, the surface layer is very dark gray loam about 6 inches thick. The subsoil is dark yellowish brown and brown, friable loam or clay loam about 20 inches thick. The substratum to a depth of about 60 inches is light olive brown and yellowish brown loam.

Included with this soil in mapping are small areas of Terril soils on foot slopes of escarpments and Coland soils along narrow streams and drainageways dissecting the uplands. These areas make up about 10 percent of this map unit.

This Lester soil is moderately permeable, and surface runoff is very rapid. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer generally is acid. The subsoil is medium in available phosphorus and very low in available potassium.

Most areas of this soil are in timber or timbered pasture. This soil is not suited to corn, soybeans, and small grains and is moderately suited to pasture and trees. Better quality woodland can be obtained by restricted grazing. Operation of farm machinery on these steep slopes is dangerous.

This soil has a severe erosion hazard if it used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion. Better quality native trees can be left where desirable.

This Lester soil is in capability subclass VIe.

253B—Farrar fine sandy loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex knolls and ridgetops. Slopes typically are short. Individual areas range from 2 to 12 acres and are irregular in shape.

Typically, the surface layer is very dark brown fine sandy loam about 7 inches thick. The subsurface layer is very dark brown fine sandy loam about 7 inches thick. The subsoil extends to a depth of about 39 inches. It is brown, very friable sandy loam in the upper part; dark yellowish brown, friable loam in the middle part; and yellowish brown, friable loam in the lower part. The substratum to a depth of about 60 inches is light yellowish brown loam.

Included with this soil in mapping are areas of Clarion soils on similar landscape positions, calcareous Storden soils on steeper soils, and sand and gravel spots that are droughty. Clarion soils have more clay in the surface layer and upper part of the subsoil. These areas make up less than 15 percent of this map unit.

Permeability of this Farrar soil is moderately rapid in the upper part and moderate in the lower part of the subsoil and the substratum. Surface runoff is medium. The available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer and subsoil typically are slightly acid or neutral. The subsoil is very low in available phosphorus and potassium. Soil tilth is excellent.

Most areas of this soil are cultivated. This soil is well suited to cultivated crops, hay, and pasture. It is droughty in some years. There is a slight hazard of wind erosion if the soil is used for cultivated crops. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility. Cultivation after heavy rains helps to prevent damage to small row crops from blowing sand. Pasture and hay are also effective in controlling erosion.

This soil has a slight erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion.

This Farrar soil is in capability subclass IIe.

259—Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained soil is on low lying positions on terraces. A few individual areas are on uplands. Typical areas are 5 to 20 acres and are irregular in shape. Some larger areas range to 100 acres or more and are long and narrow.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is also black clay loam about 8 inches thick. The subsoil, about 17 inches thick, is dark gray, mottled, friable loam and clay loam. The substratum to a depth of about 60 inches is light olive brown and grayish brown loamy sand.

Included with this soil in mapping are small areas of Talcot soils. The calcareous Talcot soils are on landscape positions similar to this Biscay soil and make up about 5 percent of the map unit.

This Biscay soil is moderately permeable in the surface layer and in most of the subsoil and is rapidly permeable in the lower part of the subsoil and in the substratum. Surface runoff is slow. The soil has a seasonal high water table. The available water capacity is moderate. The content of organic matter is about 5.5 to 6.5 percent in the surface layer. Typically, the surface layer is neutral, and the subsoil is mildly alkaline. The subsoil generally is very low in available phosphorus and very low or low in available potassium. It typically is easy to maintain good tilth.

Most areas are cultivated. If adequately drained, the soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Tile drains remove excess water. Returning crop residue or regularly adding other organic material helps to improve fertility, conserve moisture, and reduce soil blowing.

A high water table is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Droughtiness is a hazard in some years. Installing a drainage system and using supplemental irrigation as needed make it possible to select almost any species adapted to the climate of the county.

This Biscay soil is in capability subclass IIw.

274—Rolfe silt loam, 0 to 1 percent slopes. This nearly level, very poorly drained soil is in depressions of uplands. Slopes are short and concave. This soil is ponded after heavy rains. Individual areas range from 2 to 8 acres and are generally circular.

Typically, the surface layer is black silt loam about 9 inches thick. The subsurface layer is dark grayish brown and dark gray silt loam about 10 inches thick. The subsoil is about 33 inches thick. The upper part is dark gray, friable clay loam; the middle part is olive gray, mottled clay and clay loam; and the lower part is dark gray and olive, mottled sandy clay loam and clay loam. The substratum to a depth of about 60 inches is olive, mottled clay loam. On stream benches, the substratum is sandy.

This Rolfe soil is slowly permeable and ponds after heavy rains. It has a seasonal high water table. The available water capacity is high. The content of organic matter is about 3.5 to 5 percent in the surface layer. The surface layer generally is acid if not limed during the past 5 years. The subsoil is very low in available phosphorus and potassium.

Most areas of this soil are tile drained and are cultivated. Undrained areas are used as wetland wildlife habitat and pasture. This soil is moderately suited to corn, soybeans, and small grains and to grasses for hay and pasture. Many legumes experience winter kill or drown in spring if grown on this soil. Because of the slowly permeable subsoil, some tiled areas may not drain satisfactorily. Surface water intakes help to remove ponded water. Even if tile drained, this soil is susceptible to wetness and ponding after heavy rains and during spring thaws. Undrained areas provide good habitat for wetland wildlife.

Wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Adequate drainage and the selection of species that can withstand wetness are very important.

This Rolfe soil is in capability subclass IIIw.

284—Flagler sandy loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is on stream terraces and upland outwash areas. Individual areas range from 2 to 30 acres and are irregular in shape.

Typically, the surface layer is very dark brown sandy loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown sandy loam about 13 inches thick. The subsoil is about 18 inches thick. It is brown, friable sandy loam in the upper and middle parts and dark yellowish brown, friable loamy sand in the lower part. The substratum to a depth of about 60 inches is dark yellowish brown, gravelly sand. In places, the surface layer is gravelly sandy loam. In places, depth to carbonates is as shallow as 35 inches.

Included with this soil in mapping are small areas of Wadena soils that have more clay and less sand in the upper part. These areas are on similar landscape positions and make up about 5 percent of this map unit.

Permeability of this Flagler soil is moderately rapid in the upper part of the subsoil and very rapid in the lower part of the subsoil and the sandy substratum. Surface runoff is slow. The available water capacity is low. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer generally is acid if not limed in the past 5 years. The subsoil is generally very low in available phosphorus and potassium. Soil tilth is good.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. The major limitation is drought in years of normal or below normal rainfall. The soil is subject to soil blowing if cultivated. Cultivation after heavy rains helps to prevent damage to small row crops from blowing sand. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility.

This soil has a severe drought hazard if it is used for trees and shrubs grown as windbreaks, ornamental plantings, or wildlife plantings. Plantings should be limited to species that can survive in droughty soils.

This Flagler soil is in capability subclass IIIs.

284B—Flagler sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on stream terraces and upland outwash areas. Slopes are short and convex. Individual areas range from 2 to 30 acres and are irregular in shape.

Typically, the surface layer is very dark brown sandy loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown sandy loam about 13 inches thick. The subsoil is about 18 inches thick. It is brown, friable sandy loam in the upper and middle parts and dark yellowish brown, friable loamy sand in the lower part. The substratum to a depth of about 60 inches is dark yellowish brown loamy sand and sand and gravel. In places, the surface layer is gravelly sandy loam. In other places, the depth to carbonates is as shallow as 35 inches.

Permeability of this Flagler soil is moderately rapid in the upper part of subsoil and very rapid in the lower part of the subsoil and the sandy substratum. Surface runoff is medium. The available water capacity is low. The content of organic matter is about 1.5 to 2.5 percent in the surface layer. The surface layer generally is acid if not limed in the past 5 years. The subsoil is generally very low in available phosphorus and potassium. Soil tilth is good.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. The major limitations are drought and erosion. Soil blowing is a hazard if this soil is used for cultivated crops. Cultivation after heavy rains helps to prevent damage to small row crops from blowing sand. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth.

This soil has a severe drought hazard and a slight erosion hazard if it is used for trees and shrubs grown as windbreaks, ornamental plantings, or wildlife plantings. Plantings should be limited to species that can survive on droughty soils.

This Flagler soil is in capability subclass IIIe.

288—Ottosen clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slightly convex knolls on uplands. Typical areas are 2 to 10 acres and are irregular in shape. A few individual areas are 25 acres or more.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown clay loam about 10 inches thick. The subsoil is dark grayish brown, friable clay loam about 17 inches thick. The substratum to a depth of about 60 inches is dark grayish brown and olive gray, mottled loam. In places, the subsoil has thin layers of silty clay in the subsoil.

Permeability of this Ottosen soil is moderately slow in the upper part and moderate in the lower part. Surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. The surface layer and the upper part of the subsoil are typically slightly acid. The subsoil generally is very low or low in available phosphorus and potassium. It typically is easy to maintain good tilth.

Most areas of this soil are cultivated. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Tile drains installed in places help to avoid delays in field operations. It typically is easy to maintain good tilth. The use of crop residue or other organic material helps to reduce wind erosion and crusting and increase the infiltration rate. Cultivating or grazing when the soil is wet causes compaction.

Wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Normally, the limitation is slight, and most species adapted to the climate of the county can be planted.

This Ottosen soil is in capability class I.

356G—Hayden-Storden loams, 25 to 50 percent slopes. These very steep, well drained soils are on upland side slopes adjacent to major streams. Most areas are dissected by many gullies and deep drainageways. Individual areas range from 5 to 30 acres and are irregular in shape. This complex is about 50 percent Hayden loam and about 35 percent Storden loam. The Hayden soil is on north- and east-facing side slopes and ridgetops. The Storden soil is on west- and south-facing side slopes. The two soils are so intricately mixed, or the areas are so small in size, that it was not practical to separate them in mapping.

Typically, the Hayden soil has a surface layer of very dark grayish brown loam about 3 inches thick. The subsurface layer is dark grayish brown, friable loam about 5 inches thick. The subsoil is about 24 inches thick. The upper part is brown, friable loam, and the lower part is dark yellowish brown, friable loam and clay loam. The substratum to a depth of about 60 inches is yellowish brown, friable loam.

Typically, the surface layer of the Storden soil is very dark brown, calcareous loam about 9 inches thick. The subsurface layer is very dark grayish brown, calcareous loam about 8 inches thick. The substratum to a depth of about 60 inches is dark grayish brown, mottled, calcareous loam.

Included with these soils in mapping are areas that are severely eroded. Also included are small areas of gravelly outwash material that has a lower available water capacity. These areas make up less than 15 percent of this complex.

These Hayden and Storden soils are moderately permeable, and surface runoff is rapid. The available water capacity is high for both soils. The content of organic matter is about 1 to 2 percent in the surface layer of both soils. The surface layer of the Hayden soil is slightly acid or neutral, and the surface layer of the Storden soil and is mildly alkaline or moderately alkaline. The Hayden subsoil is medium in available phosphorus and very low in available potassium; and the Storden subsoil is very low in available phosphorus and potassium.

Most areas of this complex are in woodland or permanent pasture. The soils are moderately suited to trees, poorly suited to pasture, and well suited to woodland wildlife habitat. The soils are not suited to cultivation. A few areas have been cleared for pasture, but forage production is low. The soils are susceptible to severe erosion if not protected. Erosion can be kept to a minimum by maintaining a good cover on these soils.

These soils have a severe erosion hazard if they are used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to deter erosion. Better quality native trees can be left where desirable.

These Hayden and Storden soils are in capability subclass VIIe.

386—Cordova clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on upland flats adjacent to steep ravines. Individual areas range from 2 to 15 acres and are oval to irregular in shape.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black clay loam about 5 inches thick. The subsoil extends to a depth of about 41 inches. It is very dark gray, mottled, friable clay loam in the upper part and olive gray, mottled, firm clay loam in the lower part. The substratum to a depth of about 60 inches is olive gray, calcareous loam.

Included with this soil in mapping are areas of somewhat poorly drained soils on similar landscape positions that have less clay in the subsoil. These areas make up about 10 percent of the map unit.

Permeability of this Cordova soil is moderately slow. Surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 5.5 to 6.5 percent in the surface layer. The surface layer generally is slightly acid. The subsoil is low or very low in available phosphorus and very low in available potassium. Soil tilth is a problem if this soil is tilled when wet.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Drainage, including tile drainage, is needed for optimal crop production. This soil is slow to warm in the spring and can dry out cloddy and hard if worked when wet. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to maintain good tilth and increases infiltration. The selection of herbicides and their application rate is affected by the organic matter content of this soil.

This soil is moderately suited to trees. Wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Selecting species that withstand wetness and providing adequate drainage are important.

This Cordova soil is in capability subclass IIw.

388—Kossuth silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on slightly convex to slightly concave, upland slopes. Typical areas are 20 to several hundred acres and are irregular in shape.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark gray silty clay loam about 14 inches thick. The subsoil is about 13 inches thick. The upper part is dark gray, mottled, firm silty clay loam; the lower part is olive gray, mottled, firm clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled loam.

Included with this soil in mapping are many small areas of very poorly drained Okoboji soils in depressions. They make up about 10 percent of the map unit.

Permeability of this Kossuth soil is moderately slow in the surface layer, subsurface layer, and subsoil and moderate in the substratum. Surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. The surface layer and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally is low or very low in available phosphorus and potassium. The surface layer typically needs special care to maintain good tilth.

Most areas of this soil are cultivated. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture if adequately drained. Tile drains remove excess subsurface water. Conservation tillage, which leaves crop residue on the surface throughout the year, helps to maintain tilth and increase infiltration. Cultivating when this soil is too wet causes compaction and cloddiness. Returning crop residue or regularly adding other organic material helps to reduce wind erosion and crusting and increase the infiltration rate.

Wetness is the main limitation if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. It is important to plant species that can withstand wetness or to install a drainage system.

This Kossuth soil is in capability subclass IIw.

485—Spillville loam, 0 to 2 percent slopes. This nearly level, moderately well drained and somewhat poorly drained soil is on bottom lands. It is subject to flooding. Most areas are 2 to 10 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam to a depth of 60 inches. In places, lenses of loamy sand and sand are in the substratum.

This Spillville soil is moderately permeable. Surface runoff is slow. The soil has a seasonal high water table. The available water capacity is high or very high. The content of organic matter is about 4 to 5 percent in the surface layer. The soil typically is neutral or slightly acid throughout. The subsoil generally is low in available phosphorus and very low in available potassium.

Some areas of this soil are cultivated. Other areas are in pasture. If it is protected from flooding, the soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Some small areas are isolated by a meandering stream. It is not practical to use these isolated areas for cultivated crops. Returning crop residue or regularly adding other organic material helps to reduce wind erosion and crusting and increase the infiltration rate. Farm machinery can be used in most places to renovate pastures as needed. Weed control is important because of the weed seeds carried in by floodwaters.

Wetness and flooding are the main limitations if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Trees that can withstand wetness should be planted unless flooding is controlled.

This Spillville soil is in capability subclass IIw.

506—Wacousta silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions. It is subject to ponding. Typical areas are 5 to 20 acres and are irregular in shape. A few individual areas are as large as 50 acres.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black, firm silty clay loam about 5 inches thick. The subsoil is about 5 inches thick and is olive gray, mottled, friable silty clay loam. The substratum to a depth of about 60 inches dominantly is olive gray, mottled silt loam in the upper part and light gray, mottled silt loam in the lower part. In places, the surface layer is mucky silty clay loam. In other places, lenses of loamy sand and sand are in the substratum.

This Wacousta soil is moderately permeable. Surface runoff from adjacent soils is ponded. The soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 8 to 10 percent in the surface layer. Typically, the surface layer and subsurface layer are neutral, and the subsoil is neutral or mildly alkaline. The subsoil generally is very low in available phosphorus and potassium. It typically is difficult to maintain good tilth.

Most areas of this soil are cultivated. If adequate drainage is provided, the soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Surface drains or surface intakes remove excess ponded water. Tile drains improve internal drainage. Deep cuts are necessary in places to get a satisfactory outlet. Cultivation when this soil is too wet causes cloddiness and a poor seedbed. Returning crop residue or regularly adding other organic material reduces crusting and increases the infiltration rate.

Wetness and ponding are the main limitations if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. Selecting species that withstand wetness or providing adequate drainage, or both, are important.

This Wacousta soil is in capability subclass IIIw.

507—Canisteo clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is in shallow swales on uplands. Typical areas range from 2 to 100 acres and are irregular in shape.

Typically, the surface layer is black clay loam about 10 inches thick. The subsurface layer, about 13 inches thick, is black clay loam in the upper part and very dark gray silty clay loam in the lower part. The subsoil is dark gray and olive gray, mottled silty clay loam about 14 inches thick. The substratum to a depth of 60 inches is olive gray and olive, mottled clay loam in the upper part and olive gray and yellowish brown, mottled loam in the lower part. In places, the surface layer is not calcareous.

Included with this soil in mapping are small areas of very poorly drained Okoboji soils in depressions. These soils make up about 10 percent of the map unit.

This Canisteo soil is moderately permeable. Surface runoff is slow or ponded. This soil has a seasonal high water table. The available water capacity is high. The content of organic matter is about 6 or 7 percent in the surface layer. The soil typically is mildly alkaline or moderately alkaline throughout. The subsoil generally is very low in available phosphorus and potassium. The surface layer typically needs special care to maintain good tilth.

Most areas are cultivated. The soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture if adequately drained. Tile drains remove excess subsurface water. Conservation tillage, which leaves residue on the surface throughout the year, increases infiltration. Cultivating when this soil is too wet causes compaction and cloddiness. Returning crop residue or regularly adding other organic material helps to reduce wind erosion and crusting and increase the infiltration rate. Excess lime modifies crop response to fertilizer and herbicides. Iron chlorosis and herbicide carry-over damage are common in soybeans on this soil. Proper selection and use of soybean varieties, herbicides, and fertilizers minimize these problems. Larger amounts of phosphorous and potassium fertilizers are needed because of the high lime content of the soil. Soybeans can require additions of iron compounds.

Wetness and excessive amounts of lime are the main limitations if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. It is important to select species tolerant of wet, calcareous soils.

This Canisteo soil is in capability subclass IIw.

536—Hanlon fine sandy loam, 0 to 2 percent slopes. This nearly level, moderately well drained soil is on natural levees along streams. This soil is subject to flooding. Slopes are slightly convex. Individual areas range from 2 to 6 acres and are irregular in shape.

Typically, the surface layer is very dark brown fine sandy loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown fine sandy loam about 31 inches thick. The subsoil is very dark grayish brown, very friable fine sandy loam about 9 inches thick. The substratum to a depth of about 60 inches is dark grayish brown loamy sand.

Included with this soil in mapping are small areas on similar landscape positions that have calcareous surface horizons, which affect crop response to fertilizer and herbicides. Also included are areas of Spillville soil on similar landscape positions that contain less sand and more clay. These areas make up about 12 percent of this map unit.

Permeability of this Hanlon soil is moderately rapid. Surface runoff is slow. The available water capacity is moderate. The content of organic matter is about 2 or 3 percent in the surface layer. The soil is neutral or slightly acid. The subsoil is very low in available phosphorus and potassium. Tilth is good.

This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. It is somewhat droughty during extended dry periods. The soil is subject to flooding of short duration. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, helps to prevent excessive soil loss from spring floods. Returning crop residue or regularly adding other organic material helps to improve fertility and maintain good tilth. Areas that frequently flood or that are associated with soils shallow to limestone bedrock are often used for pasture.

This soil has a drought hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. Mulch cover helps to conserve moisture.

This Hanlon soil is in capability subclass IIs.

559—Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is in swales on wide, upland drainageways and on terraces. Individual areas range from 2 to 10 acres and are irregular in shape.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 11 inches thick. The subsoil, about 16 inches thick, is dark gray, friable clay loam in the upper and middle parts and olive gray and dark gray, friable sandy loam in the lower part. The substratum to a depth of about 60 inches is olive and light olive gray sand. In places, the substratum is loam.

This Talcot soil is moderately permeable in the solum and rapidly permeable in the substratum. Surface runoff is slow or ponded. The soil has a seasonal high water table. The available water capacity is moderate. The content of organic matter is about 5.5 to 6.5 percent in the surface layer. The soil is moderately alkaline throughout. The subsoil generally is very low in available phosphorus and potassium. The surface layer typically needs special care to maintain good tilth.

Some areas of this soil are cultivated. Other areas are in pasture. The soil is moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture if adequately drained. Tile drains remove excess subsurface water. Excess lime modifies crop response to fertilizer and herbicides. Iron chlorosis and herbicide carry-over damage are common in soybeans on this soil. Proper selection and use of soybean varieties, herbicides, and fertilizers minimize these problems. Cultivating when this soil is too wet causes compaction and cloddiness. Returning crop residue or regularly adding other organic material helps to reduce wind erosion and crusting and increase the infiltration rate. Larger additions of phosphorous and potassium fertilizers are needed because of the high lime content of the soil. Soybeans can require additions of iron compounds.

Wetness and excess lime are the main limitations if this soil is used for trees and shrubs grown as windbreaks and ornamental plantings. It is important to select species that can withstand wet, calcareous soils.

This Talcot soil is in capability subclass IIw.

638C2—Clarion-Storden loams, 5 to 9 percent slopes, moderately eroded. These gently rolling, well drained soils are on knobs, ridgetops, and side slopes of uplands. Slopes typically are short. Individual areas range from 2 to 50 acres and are irregular in shape. This complex is 50 percent Clarion soil, 40 percent Storden soil, and 10 percent other soils. The Clarion soil is on ridgetops, in concave swales, and on lower side slopes. The Storden soil is on the more sloping convex knobs and upper side slopes. The two soils are so intricately mixed, or areas are so small in size, that it was not practical to separate them in mapping. The eroded knobs of Storden soil are lighter in color. A grower can selectively apply fertilizer with a high rate of phosphorus to correct the deficiency for a number of years.

Typically, the surface layer of the Clarion soil is very dark grayish brown loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is friable loam about 16 inches thick. The upper and middle parts are brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is yellowish brown to light olive brown, friable, calcareous loam.

Typically, the Storden soil has a surface layer of dark grayish brown, calcareous loam about 8 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. The substratum to a depth of about 60 inches is light olive brown, friable, calcareous loam. In places, the surface layer has less organic matter and the soil is slightly acid in the surface layer and upper part of the substratum.

Included with these soils in mapping are small areas of droughty Zenor soils on high knobs and small areas of Okoboji, Rolfe, and Webster soils in depressions and swales that need tile drainage. These soils make up about 10 percent of this complex.

These Clarion and Storden soils are moderately permeable. Surface runoff is medium. The available water capacity is high. The content of organic matter in the Clarion soil is about 1 to 2.5 percent in the surface layer; the content of organic matter in the Storden soil is less than 0.5 percent in the surface layer. The surface layer of the Clarion soil is slightly acid or neutral. The surface layer of the Storden soil is calcareous and mildly alkaline. The subsoil of both soils is very low in available phosphorus and potassium. Excess lime in the surface layer of the Storden soil affects crop response to fertilizer and herbicides. Soil tilth typically is good; however, surface crusting is a problem after heavy rains.

Most areas of these soils are cultivated. These soils are moderately suited to corn, soybeans, small grains, and grasses and legumes for hay and pasture.

If these soils are used for cultivated crops, there is a hazard of further erosion damage. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult because of the undulating topography and short slopes, but in most places these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce crusting, and increase water infiltration. The use of these soils for pasture or hay is also effective in controlling erosion.

If these soils are used for trees and shrubs grown as windbreaks or ornamental plantings, the hazard of erosion is severe. A mulch cover helps to deter erosion.

These soils are in capability subclass IIIe.

638D2—Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded. These strongly sloping, well drained soils are on knobs, ridgetops, and side slopes of uplands. Slopes typically are short. Individual areas range from 2 to 30 acres and are irregular in shape. This complex is 50 percent Clarion soil, 40 percent Storden soil, and 10 percent other soils. The Clarion soil is on ridgetops, concave swales, and lower side slopes. The Storden soil is on the more sloping, convex knobs and upper side slopes. The two soils are so intricately mixed, or areas are so small in size, that it was not practical to separate them in mapping. The eroded knobs of Storden soil can be readily identified by the lighter color. A grower can selectively apply fertilizer with a high rate of phosphorus and correct the deficiency for a number of years.

Typically, the surface layer of the Clarion soil is very dark grayish brown or very dark brown loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is dark yellowish brown, friable loam about 14 inches thick. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam.

Typically, the Storden soil has a surface layer of dark grayish brown, calcareous loam about 8 inches thick. It is mixed with streaks and pockets of light olive brown substratum material. The substratum to a depth of about 60 inches is light olive brown, friable, calcareous loam. In places, the surface layer has less organic matter and is slightly acid.

Included with these soils are small areas of Zenor soils on high knobs that are droughty and areas of Okoboji, Rolfe, and Webster soils in depressions and swales that need tile drainage. These areas make up about 10 percent of this complex.

These Clarion and Storden soils are moderately permeable. Surface runoff is rapid. The available water capacity is high. The content of organic matter in the Clarion soil is about 1 to 2.5 percent in the surface layer; the content of organic matter in the Storden soil is less than 0.5 percent in the surface layer. Typically, the surface layer of the Clarion soil is slightly acid or neutral, and the surface layer of the Storden soil is mildly alkaline and calcareous. The subsoil of both soils typically is very low in available phosphorus and potassium. Excess lime in the surface layer of the Storden soil affects crop response to fertilizer and herbicides. Soil tilth typically is good; however, surface crusting is a problem after heavy rains.

Most areas of these soils are cultivated. These soils are moderately suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. If these soils are used for cultivated crops, there is a hazard of further erosion damage. Conservation tillage, a practice that leaves crop residue on the surface throughout the year, and grassed waterways help to prevent excessive soil loss. Contouring and terracing are difficult because of the undulating topography and short slopes; in some places, however, these practices are suited. Returning crop residue or regularly adding other organic material helps to improve fertility, reduce crusting, and increase water infiltration. The use of these soils for pasture or hay is also effective in controlling erosion.

These soils have a severe erosion hazard if they are used for trees and shrubs grown as windbreaks or ornamental plantings. A mulch cover helps to deter erosion.

These Clarion and Storden soils are in capability subclass IIIe.

828B—Zenor sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on knolls and side slopes of upland ablation till and glacial outwash areas. Individual areas range from 2 to 5 acres and are irregular in shape.

Typically, the surface layer is very dark brown sandy loam about 8 inches thick. The subsurface layer is very dark grayish brown, friable sandy loam about 3 inches thick. The subsoil is about 18 inches thick. The upper part is dark brown, very friable sandy loam; the middle part is brown, very friable sandy loam; and the lower part is dark yellowish brown, very friable loamy sand. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown loamy sand in the upper part and gravelly loamy sand in the lower part. The gravel content ranges from 5 to 15 percent throughout.

Included with this soil in mapping are a few small areas of Storden soils on steeper slopes that are calcareous within 10 inches of the surface. The Storden soils contain more clay throughout and have a higher available water capacity. A few small, severely eroded areas are included that have a lower available water capacity. These areas make up about 15 percent of this map unit.

Permeability of this Zenor soil is moderately rapid. Surface runoff is slow. The available water capacity is moderate. The content of organic matter is about 2 or 3 percent in the surface layer. The surface layer is slightly acid or neutral. The subsoil is very low in available phosphorus and potassium. The surface layer is friable and easily tilled through a wide range in moisture content.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, small grains, and grasses and legumes. When used for cultivated crops, erosion and soil blowing are hazards. Soil loss can be reduced significantly by using conservation tillage, which is a practice that leaves crop residue on the surface throughout the year, contour farming, terraces, crop rotation, or stripcropping, or a combination of these practices. Conservation tillage reduces soil blowing. Returning crop residue helps to maintain good tilth and increases water infiltration. In cultivated areas, the selection of herbicides and their rate of application is affected by the sand content of the soil.

This soil has a moderate erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. Droughtiness is a slight hazard. A mulch cover helps to deter erosion.

This Zenor soil is in capability subclass IIIe.

828C2—Zenor sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is on knolls and side slopes of upland ablation till and glacial outwash areas. Individual areas range from 2 to 5 acres and are irregular in shape.

Typically, the surface layer is dark brown and brown sandy loam about 8 inches thick. It is mixed with subsoil material. The subsoil is about 25 inches thick. It is brown, very friable sandy loam in the upper part and yellowish brown, very friable loamy sand in the lower part. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown loamy sand and gravelly loamy sand. The gravel content ranges from 5 to 15 percent throughout.

Included with this soil in mapping are a few small areas of Storden soils on similar landscape positions that are calcareous within 10 inches of the surface. The Storden soils contain more clay throughout and have a higher available water capacity. A few small severely eroded areas and some small sand areas are also included. These areas have a lower available water capacity. Included areas make up about 15 percent of the map unit.

Permeability of this Zenor soil is moderately rapid. Surface runoff is medium. The available water capacity is moderate. The content of organic matter is about 1 to 1.5 percent in the surface layer. The surface layer is slightly acid or neutral. The subsoil is very low in available phosphorus and potassium. The surface layer is friable and easily tilled through a wide range in moisture content.

Most areas of this soil are cultivated. This soil is moderately suited to corn, soybeans, small grains, and grasses and legumes. This soil is moderately eroded, and soil losses are likely to be excessive if the soil is not protected by vegetation or conservation measures. In places, gullying is a hazard. Soil loss can be reduced significantly by using conservation tillage, which is a practice that leaves crop residue on the surface throughout the year, contour farming, terraces, crop rotation, or stripcropping, or a combination of these practices. Conservation tillage reduces soil blowing. Returning crop residue helps to maintain good tilth, conserve moisture, and increase water infiltration. This soil is droughty in years of below normal rainfall or during extended dry periods. In cultivated areas, the selection of herbicides and their rate of application is affected by the sand content of this soil.

This soil has a severe erosion hazard if it is used for trees and shrubs grown as windbreaks and ornamental plantings. Droughtiness is a slight hazard. A mulch cover helps to deter erosion.

This Zenor soil is in capability subclass IIIe.

956—Harps-Okoboji complex, 0 to 2 percent slopes. These nearly level, poorly drained and very poorly drained soils are in depressions and on the adjacent rims of depressions in uplands. Individual areas range from 3 to 150 acres and are irregular in shape. This complex contains about equal parts of Harps and Okoboji soils. They are in the depressions. Harps soils are on the adjacent high lime rims. Okoboji soils are subject to ponding. The two soils are so intricately mixed, or areas are so small in size, that it was not practical to separate them in mapping.

Typically, the surface layer of the Harps soil is black, calcareous clay loam about 8 inches thick. The subsurface layer is very dark gray, calcareous clay loam about 12 inches thick. The subsoil is about 21 inches thick. It is light olive gray and olive gray, mottled, friable, calcareous loam. The substratum to a depth of 60 inches is light olive gray, mottled, calcareous loam.

Typically, the surface layer of the Okoboji soil is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 24 inches thick. The subsoil is about 15 inches thick. It is dark gray and gray, mottled, friable silty clay loam. The substratum to a depth of about 60 inches is light gray and gray, mottled, calcareous silty clay loam. In places, the surface layer is mucky silt loam.

Permeability of the Harps soil is moderate, and permeability of the Okoboji soil is moderately slow. The soils have a seasonal high water table. The available water capacity is high. These soils are ponded after heavy rains and during spring thaws. Shrink-swell potential is high for the Okoboji soil. The content of organic matter is about 9 to 18 percent in the surface layer of the Okoboji soils and 4 to 5 percent in the surface layer of the Harps soil. These soils are mildly alkaline or moderately alkaline and do not need lime. The subsoil of both soils is very low in available phosphorus and potassium. In many places, the available iron is not sufficient for soybeans on the Harps soil. Tilth is a problem if these soils are tilled when wet.

Most areas of these soils are drained with tile or drainage ditches and are cultivated. These soils are suited to corn, soybeans, and grasses for hay and pasture. Most legumes experience winter kill or drown in the spring if grown in the depressions of these soils. Ponding, wetness, and excess lime are the major limitations for crop production. Surface water tile intakes or surface drains help to minimize crop damage from ponding. There is a danger of early frost in the fall on these soils. Iron chlorosis and herbicide carry-over damage are common in soybeans on the Harps soil. Proper selection and use of soybean varieties, herbicides, and fertilizer minimize these problems.

Wetness and excess lime are the main limitations if this soil is used for trees and shrubs grown as windbreaks or ornamental plantings. Species that withstand wet, calcareous soils should be selected.

These Harps and Okoboji soils are in capability subclass IIIw.

1178—Waukee Variant loam, 0 to 2 percent slopes. This nearly level, well drained soil is on stream terraces and uplands. Individual areas range from 2 to more than 100 acres and are irregular in shape.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark brown loam about 14 inches thick. The subsoil is brown, friable loam to a depth of about 83 inches.

This Waukee Variant soil is moderately permeable. Surface runoff is slow. The available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. The surface layer ranges from neutral to medium acid depending on past liming practices. The subsoil is medium acid or strongly acid. The subsoil is very low in available phosphorus and potassium. This soil has good tilth.

Most areas of this soil are cultivated. This soil is well suited to corn, soybeans, and small grains and to grasses and legumes for hay and pasture. Returning crop residue or regularly adding other material helps to improve fertility and maintain good tilth.

This soil is well suited to trees and shrubs grown as windbreaks and ornamental plantings.

This Waukee Variant soil is in capability class I.

1314—Hanlon-Spillville complex, channeled, 0 to 2 percent slopes. These nearly level, moderately well drained and somewhat poorly drained soils are on flood plains that are dissected by meandering stream channels. Areas of these soils are subject to flooding. Individual areas range from 15 to 150 acres and are long and narrow. This complex is about 50 percent Hanlon soil, 40 percent Spillville soil, and 10 percent minor soils. The Spillville soil is on the slightly concave, lower parts of the flood plains. The Hanlon soil is on the slightly convex, natural levees adjacent to the stream channels. Areas of the two soils are so intricately mixed or small in size that it was not practical to separate them in mapping.

Typically, the surface layer of the Hanlon soil is very dark brown fine sandy loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown fine sandy loam about 31 inches thick. The subsoil is very dark grayish brown, very friable fine sandy loam about 9 inches thick. The substratum to a depth of about 60 inches is dark grayish brown loamy sand.

Typically, the surface layer of the Spillville soil is black loam about 8 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam. The substratum below a depth of about 60 inches is very dark grayish brown loam. In places, lenses of loamy sand and sand are in the substratum. In other places, these channeled soils have more clay.

Permeability of the Hanlon soil is moderately rapid, and permeability of the Spillville soil is moderate. Surface runoff is slow. The Spillville soil has a seasonal high water table. The available water capacity is high or moderate. The content of organic matter is about 2 or 3 percent in the surface layer of the Hanlon soil and 4 to 6 percent in the surface layer of the Spillville soil. The soil is neutral or slightly acid and seldom needs lime. The subsoil is very low in available phosphorus and potassium. Tilth is good.

Most areas of these soils are in pasture. The soils are poorly suited to cultivated crops and moderately suited to pasture. It is susceptible to wetness caused by flooding and a high water table. There are great variations in texture, organic matter content, fertility requirements, and drainage needs. Meandering stream channels and flooding are the major hazards for crop production. The soils in this complex are somewhat droughty during extended dry periods.

These soils have a drought hazard if they are used for trees and shrubs grown as windbreaks and ornamental plantings. A mulch cover helps to conserve moisture.

These Hanlon and Spillville soils are in capability subclass Vw.

1585—Spillville-Coland complex, channeled, 0 to 2 percent slopes. These nearly level, moderately well drained to poorly drained soils are on flood plains that are dissected by meandering stream channels. Areas of these soils are subject to flooding. Individual areas range from 15 to 30 acres and are long and narrow. This complex is about 50 percent Spillville soil, 40 percent Coland soil, and 10 percent minor soils. The Coland soil is on the slightly concave, lower parts of the flood plains. The Spillville soil is on the slightly convex, natural levees adjacent to the stream channels. Areas of the two soils are so intricately mixed or small in size that it was not practical to separate them in mapping.

Typically, the surface layer of the Spillville soil is black loam about 8 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown, friable loam to a depth of about 60 inches.

Typically, the surface layer of the Coland soil is black clay loam about 8 inches thick. The subsurface layer, about 39 inches thick, is black clay loam in the upper part and very dark gray, mottled clay loam in the lower part. The substratum to a depth of about 60 inches is olive gray, mottled clay loam.

Included with these soils in mapping on similar landscape positions are areas of Hanlon soils that contain more sand. These areas make up about 10 percent of this complex.

These soils are moderately permeable. Surface runoff is slow. The soils have a seasonal high water table. The available water capacity is high. Shrink-swell potential is high for the Coland soil. The content of organic matter is about 4 to 6 percent in the surface layer of the Spillville soil and 5 to 7 percent in the surface layer of the Coland soil. The soils are neutral or slightly acid. Below the surface layer, these soils are low in available phosphorus and very low in available potassium. These soils have good tilth.

Most areas of these soils are in pasture (fig. 12). A few areas are far from the present stream channel and are not frequently flooded. These areas are farmed. Most areas of these soils are poorly suited to cultivated crops and moderately suited to pasture. They are susceptible to wetness caused by flooding and a high water table. There are considerable variations in texture, organic matter content, fertility requirements, and drainage needs for this complex. Meandering stream channels and flooding are the major hazards for crop production. If flooding is controlled, old stream channels are filled, and the brush and trees are cleared, these soils are well suited to row crops.

Wetness and flooding are the main limitations if these soils are used for trees and shrubs grown as windbreaks or ornamental plantings. Unless flooding is controlled, trees that can withstand wetness should be planted.

These Spillville and Coland soils are in capability subclass Vw.

4000—Urban land. This map unit is areas that are 75 percent or more covered by streets, parking lots, buildings, and other structures that obscure the soil so that identification is not feasible. Residential dwellings on standard-sized lots are a very minor part of this map unit.

Most of this map unit is the downtown part of the city of Ames. The adjoining map units indicate that the area originally was soils that developed in uplands and on terraces and bottom lands. It is probable that much of the original surface and subsurface layers and even the subsoil and substratum were disturbed in the process of urban development. Onsite investigation is needed to determine physical and chemical properties. Interpretations based on these properties can differ from those given for individual soils in Story County.

This map unit is not assigned to a capability subclass.

5010—Pits, gravel. A majority of these gravel pits are inactive, but some are still being mined. Most of the pits are on stream terraces, but some are on uplands. They range from less than an acre to more than 40 acres and commonly are square or rectangular.

Most of the pits have a seasonal high water table, and they often have ponded water in low lying areas during wet seasons. However, they tend to be droughty during much of the growing season. Stones and cobbles are common in most places. The soil is moderately alkaline.

Most of the inactive pits have a growth of weeds and small trees. Some have been used as refuse dumps. The pits have potential for development as wildlife habitat or recreation areas. Species of trees and shrubs selected for plantings must be able to withstand high amounts of lime and droughtiness.

This map unit is not assigned to a capability subclass.

5030—Pits, quarry. These pits are 10 to 50 feet deep or more. Piles of spoil a few feet high to more than 30 feet high are in and surrounding the mined areas. The pits range from a few acres to as much as 100 acres and are irregular. Some of the pits contain water from a few feet to many feet deep. Sidewalls are nearly vertical. The pits are areas where limestone has been quarried and used primarily for road building and agricultural liming. The pits with water are pumped dry during the

Figure 12.—Soils of the Spillville-Coland complex, channeled, 0 to 2 percent slopes, are commonly used as pasture and woodland.

quarrying process and often allowed to refill with water when not in use or when vacated.

The spoil surrounding the pits is variable in texture; however, it is mostly loamy and contains limestone fragments. The spoil is generally loamy alluvial sediment, loam glacial till, or a mixture of the two. In most places, spoil has not been leveled or smoothed and is very uneven. The excavated spoil ranges from slightly acid to moderately alkaline. Vacated quarries and spoil piles generally become covered with cottonwood trees and grass over a length of time. These areas are difficult to revegetate without land leveling.

These areas have good potential for wildlife. The quarries that contain water can support fish but, because of the steepness of the sidewalls and variable depth of water, they may be dangerous and have limited value for recreation. Each area would need onsite investigations to determine safety. Areas that have trees provide good woodland wildlife habitat, especially for deer.

This map unit is not assigned to a capability subclass.

5040—Orthents, loamy. This map unit consists of areas that are disturbed by man but are still suitable for plant growth. It includes borrow areas, cut and fill areas, and reclaimed gravel pits. Areas are about 2 to 20 acres and commonly are square or rectangular; some areas are irregular.

The soil material is quite variable, but most is derived from loamy glacial till. Typically, it is moderately alkaline and calcareous and contains less than 1 percent organic matter. However, in areas where topsoil has been replaced, the soil is neutral or slightly acid, and content of organic matter is 2 percent or more in the surface layer. The soil material is compacted in many areas.

Most areas of this map unit that have not been converted to urban use could be used for corn and soybeans. However, many areas are better suited to hay or pasture, at least until tilth and fertility are improved. Sloping areas are subject to erosion if they are used for corn and soybeans.

Some areas are suitable for wildlife habitat or woodland. Special care is needed in selecting species adapted to the soil conditions at the specific site.

This map unit is not assigned to a capability subclass.

5050—Orthents, sandy. This map unit includes sanitary landfills at the eastern edge of the city of Ames. Much of the area has been filled, covered with sandy soil material, and leveled. In places, topsoil has been placed over the surface to improve grass and crop production. Most areas are covered with grass or cottonwood trees and remain idle.

This map unit is not assigned to a capability subclass.

5060—Pits, clay. This map unit consists of areas mined for shale, which is used primarily for brick and tile manufacturing. In places, there are shallow, permanent, or intermittent ponds that have water less than 3 feet deep. Permanent ponds that contain water more than 3 feet deep are shown on the soil map as *Water* or *W*.

Most of these pits support little vegetation. Pumping is required to lower the water level during mining operations.

This map unit is not assigned to a capability subclass.

Prime Farmland

Prime farmland is one of several kinds of important farmlands defined by the U. S. Department of Agriculture. It is of major importance in providing the Nation's short- and long-range needs for food and fiber. The supply of high quality farmland is limited, and the U. S. Department of Agriculture recognizes that government and individuals must encourage and facilitate the use of our Nation's prime farmland with wisdom and foresight.

Prime farmland, as defined by the U. S. Department of Agriculture, is the land that is best suited to producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply needed to economically produce a sustained high yield of crops when it is treated and managed using acceptable farming methods. Prime farmland produces the highest yields with minimal inputs of energy and money. Farming it results in the least damage to the environment.

Prime farmland may now be in crops, pasture, woodland, or other land, but not urban and built-up land or water areas. It must either be used for producing food or fiber or be available for these uses.

Prime farmland usually has an adequate and dependable supply of moisture from precipitation or irrigation. Temperature and growing season are favorable. It has acceptable reaction and few or no rocks, and it is permeable to water and air. Prime farmland is not excessively erodible. It is not saturated with water for long periods and is not frequently flooded during the growing season. Slope ranges mainly from 0 to 6 percent.

About 275,000 acres, or approximately 75 percent, of Story County meets the soil requirements for prime farmland. Areas are throughout the county. Approximately 250,000 acres of this prime farmland is used for crops. Crops grown on this land, mainly corn and soybeans, account for an estimated two-thirds of the county's total agricultural income each year.

A recent trend in land use in some parts of the county has been the loss of some prime farmland to industrial and urban uses (fig. 13). The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, more droughty, and more difficult to cultivate and are usually less productive.

Soil map units that make up prime farmland in Story County are listed in this section. This list does not constitute a recommendation for a particular land use. The extent of each listed map unit is shown in table 4. The location is shown on the detailed soil maps in the back of this publication. The soil qualities that affect use and management are described in the section "Detailed Soil Map Units."

Soils that have limitations—a high water table, flooding, or inadequate rainfall—may qualify for prime farmland if these limitations are overcome by such measures as drainage, flood control, or irrigation. In the following list, the measures used to overcome limitations, if any, are shown in parentheses after the map unit name. Onsite evaluation is necessary to see if these limitations have been overcome by corrective measures.

The map units that meet the soil requirements for prime farmland are:

27B	Terril loam, 2 to 5 percent slopes
52B	Bode clay loam, 2 to 5 percent slopes
54	Zook silty clay loam, 0 to 2 percent slopes (where drained and adequately protected from flooding)
55	Nicollet loam, 1 to 3 percent slopes
95	Harps loam, 1 to 3 percent slopes (where drained)
107	Webster clay loam, 0 to 2 percent slopes (where drained)
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes
135	Coland clay loam, 0 to 2 percent slopes (where drained and adequately protected from flooding)
136B	Ankeny fine sandy loam, 2 to 5 percent slopes
138B	Clarion loam, 2 to 5 percent slopes
168B	Hayden loam, 2 to 5 percent slopes

Figure 13.—Urban development competes with agriculture for use of prime farmlands in much of Story County.

175	Dickinson fine sandy loam, 0 to 2 percent slopes
175B	Dickinson fine sandy loam, 2 to 5 percent slopes
202	Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
236B	Lester loam, 2 to 5 percent slopes
253B	Farrar fine sandy loam, 2 to 5 percent slopes
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
288	Ottosen clay loam, 1 to 3 percent slopes
386	Cordova clay loam, 0 to 2 percent slopes (where drained)
388	Kossuth silty clay loam, 0 to 2 percent slopes (where drained)
485	Spillville loam, 0 to 2 percent slopes
506	Wacousta silty clay loam, 0 to 1 percent slopes (where drained)
507	Canisteo clay loam, 0 to 2 percent slopes (where drained)
536	Hanlon fine sandy loam, 0 to 2 percent slopes
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
1178	Waukee Variant loam, 0 to 2 percent slopes

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops and Pasture

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed Soil Map Units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

In 1979, about 294,000 acres in Story County was used as cropland (*3*). Most of this acreage was used for row crops, mainly corn and soybeans. Acreage in pasture, woods, hay, and other close growing crops has decreased markedly in recent years as land use has shifted to grain production.

Crop production and conservation of soil resources could be increased by extending existing technology to all cropland in the county. This soil survey gives the basic characteristics of each kind of soil and can greatly aid in the application of such technology.

Soil erosion by running water is the major soil problem on about 42 percent of the cropland and pasture in Story County. In addition, many of the level or nearly level soils are subject to wind erosion if not protected. Loss of the topsoil through erosion is damaging for many reasons. Productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into the plow layer. Loss of the surface layer is especially damaging to soils that have a limited depth of favorable material for root development. Flagler and Zenor soils, for example, have limited root zones because of insufficient depth to the underlying sand and gravel. Topsoil lost by erosion often becomes a damaging pollutant. By controlling erosion, pollution of streams by sediment can be reduced. Water quality will improve for municipal and recreational use and for fish and wildlife.

Ideal erosion control practices provide protective surface cover, reduce runoff, and increase infiltration. A cropping system that keeps a vegetative cover on the soil for extended periods can often hold erosion losses to amounts that will not reduce the productive capacity of the soils.

On livestock farms, which require pasture and hay, the legume and grass forage crops in the cropping system reduce erosion on sloping land and provide nitrogen and improve tilth for the following crop. Maximum grass and legume production can be accomplished with correct treatment and use of pasture and hayland. Proper management practices for established stands include adequate fertilization, weed and brush control, rotational and deferred grazing with full-season grazing systems, proper stocking rates, and adequate livestock watering facilities. A severe erosion hazard exists when sloping pasture and haylands are renovated by destroying the vegetative cover. If cultivated crops are grown prior to seeding, soil losses can be reduced by using conservation tillage, contouring, and grassed waterways. In addition, interseeding grasses and legumes into existing sod eliminates the need to destroy vegetative cover for seedbed preparation. The most common adapted plant species for pasture are: bromegrass, bluegrass, reed canarygrass, orchardgrass, switchgrass, big bluestem, indiangrass, alfalfa, crownvetch, and Ladino clover.

Story County has a variety of soils and landscape features. Many slopes are so short, steep, and irregular that contour tillage or terracing is not practical.

Conservation tillage leaves crop residue on the surface and helps to increase infiltration and reduce the hazards of runoff and erosion. Examples of major conservation tillage systems include—

- *no-till, slot, or zero tillage*—With this system, preparation of the seedbed and planting is completed in one operation. There is little or no soil disturbance except in the immediate area of the planted seed row. A protective cover of crop residue is left on at least 90 percent of the soil surface.
- *strip-till*—With this system, seedbed preparation and planting are completed in one operation. Tillage in the row is limited to a strip not wider than 1/3 of the total area. A protective cover of crop residue is left on two-thirds of the soil surface.
- *chisel-disk or rotary tillage*—This system loosens the soil over the entire surface and partially incorporates the residue into the soil. Seedbed preparation and planting may be in one or in separate operations. Conservation tillage is not practiced unless enough residue is left on the soil surface after planting to effectively reduce erosion.

Terraces and diversions reduce the length of slope and control runoff and erosion. They are most adaptable and practical on well drained soils that have smooth slopes on gently sloping to moderately sloping topography. Gently sloping and moderately sloping areas of Clarion, Lester, Hayden, and Storden soils are well suited to terracing (fig. 14). Topsoil should be stockpiled during terrace construction and the exposed subsoil re-covered when the terraces are completed.

Soil blowing is a hazard on Dickinson, Flagler, Sparta, and Zenor soils. Soil blowing can damage these soils in a relatively short time if winds are strong and soils are dry and bare of vegetation or surface mulch. Crops on these soils and adjacent heavier textured soils are often damaged by blowing sand. Although it is not so evident, many of the nearly level, heavier textured soils, such as Harps, Canisteo, and Webster, are also subject to wind erosion damage under some conditions. This usually occurs when these soils are cropped to soybeans and then tilled in the fall. Maintaining a vegetative cover, surface mulch, or rough surfaces through proper tillage minimizes soil blowing on all of these soils.

Information for the design of erosion control practices for each kind of soil is contained in the Technical Guide, which is available in local offices of the Soil Conservation Service.

Soil drainage is the major management problem on about 36 percent of the soils in Story County. Examples of upland soils that are naturally wet and poorly drained are Kossuth, Harps, Canisteo, and Webster soils. Wacousta, Palms, and Okoboji soils are in upland depressions where drainage outlets are often difficult to obtain. Other soils in waterways and bottom lands are poorly drained. These include Coland and Zook soils. Poorly drained soils on the terraces or terraces that are underlain by sand and gravel include the Biscay and Talcot soils.

Soil fertility problems vary widely in Story County. Most of the well drained, upland soils are naturally acid; an exception is the Storden soil, which is alkaline. Naturally poorly drained and very poorly drained soils are commonly about neutral in pH, but some soils, such as Harps soils, are alkaline. Acid soils require the application of ground limestone to raise the pH sufficiently for good plant growth. Available potash and phosphorus levels vary widely but are particularly low on the wet alkaline soils, such as Canisteo and Harps soils.

The available subsoil phosphorus and potassium are low or very low in most soils of the uplands in the survey area. The Hayden soils are medium in available subsoil phosphorus. Most medium textured, well drained and somewhat poorly drained, upland soils that have slopes of less than 5 percent developed under the influence of grass vegetation and have about 3 to 6 percent organic matter content. Most coarse textured and moderately coarse textured upland soils have from less than 1 percent to 2 percent organic matter content. Most medium textured soils developed under the influence of grass and timber vegetation and have between 1 and 3 percent organic matter content. The Palms soils, which are very poorly drained and organic, have more than 20 percent organic matter content. Poorly drained upland soils, such as Webster and Kossuth soils, are neutral in reaction and contain from 6 to 10 percent organic matter content. Most other upland soils are acid in the subsoil and require applications of ground limestone to raise the pH level sufficiently for good growth of alfalfa and other crops that produce best on near neutral soils.

Most well drained and somewhat poorly drained, medium textured soils developed from alluvium have 2 to 5 percent organic matter content and are slightly acid to neutral in the subsoil. Poorly drained soils developed

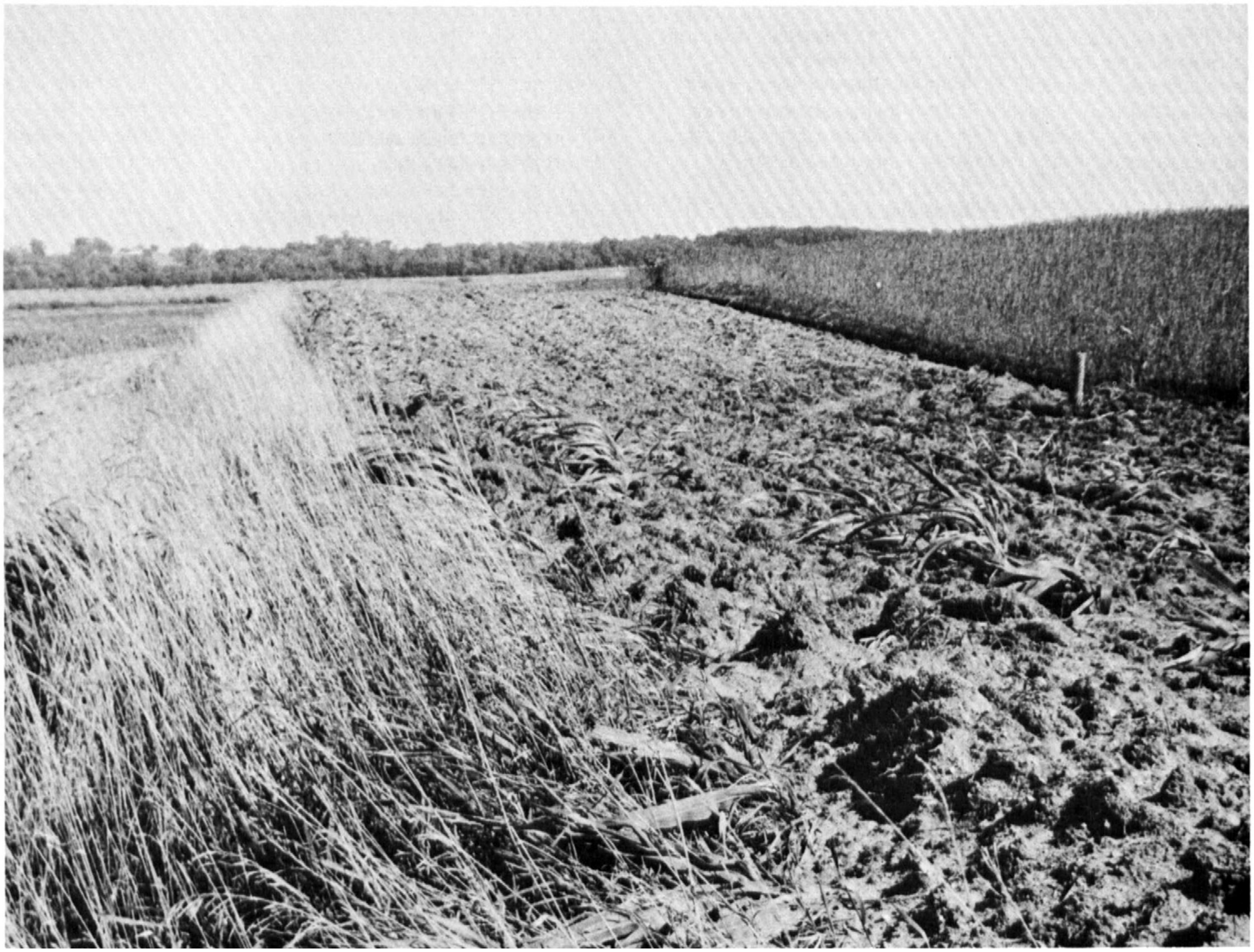


Figure 14.—A seeded, grassed, backslope tile outlet terrace provides erosion control.

from alluvium, such as Coland and Biscay soils, are neutral in reaction and have about 5 to 6 percent organic matter content. Alluvial soils in the survey area are low or very low in available subsoil phosphorus and potassium.

On all soils, additions of lime and fertilizer should be based on results of soil tests, the need of the crop, and the expected level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime to apply.

Soil tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Soils with good tilth are granular, generally high in organic matter content, and porous. Regular additions of crop residue, manure, and other organic material can help to improve soil structure and reduce crust formation.

Fall plowing is a questionable practice on many Story County soils. Sloping soils are subject to damaging erosion if they are plowed in the fall. Also, many nearly level soils that have been cropped to soybeans are vulnerable to wind erosion damage if tilled in the fall.

Field crops suited to the soils and climate of the Story County area include many that are not commonly grown. Corn and soybeans are by far the most common crops. Oats is the most common close-growing crop. Wheat, grain sorghum, sunflowers, potatoes, sugar beets, and popcorn can be grown if economic conditions are favorable. Rye, barley, buckwheat, and flax could be grown, and grass seed could be produced from bromegrass, redtop, bluegrass, switchgrass, big bluestem, and indiangrass.

Specialty crops grown commercially in Story County are limited. At present some small truck farms, tree nurseries, and apple orchards are the main specialty crops. Most of the well drained soils in the survey area are suitable for orchards. Soils in low positions, where frost is frequent and air drainage is poor, generally are poorly suited to early vegetables, small fruits, and orchards.

Latest information and suggestions for growing specialty crops can be obtained from local offices of the Cooperative Extension Service and the Soil Conservation Service.

Yields Per Acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; and harvesting that insures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for woodland or for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-4 or IIIe-6.

The acreage of soils in each capability class and subclass is shown in table 6. The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Windbreaks and Environmental Plantings

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, hold snow on the fields, reduce energy requirements, and provide food and cover for wildlife.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. To insure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

Table 7 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 7 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a nursery.

Recreation

The soils of the survey area are rated in table 8 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites (fig. 15), and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 8, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 8 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 11 and interpretations for dwellings without basements and for local roads and streets in table 10.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking, horseback riding, and bicycling should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Figure 15.—This manmade pond, surrounded by Lester soils, provides recreational use and wildlife habitat in McFarland Park.

Wildlife Habitat

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 9, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, wheat, oats, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, orchardgrass, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, wheatgrass, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, apple, hawthorn, dogwood, hickory, blackberry, and elderberry. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

Coniferous plants furnish browse and seeds. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, wildrice, cordgrass, rushes, sedges, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, cottontail, and red fox.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, woodcock, thrushes, woodpeckers, squirrels, gray fox, raccoon, and deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, muskrat, mink, and beaver.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of

Figure 16.—The low strength, ponding, and frost action properties of Okoboji soils resulted in this unstable railroad bed, which caused a train derailment.

construction conditions; (3) evaluate alternative routes for roads (fig. 16), streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building Site Development

Table 10 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the

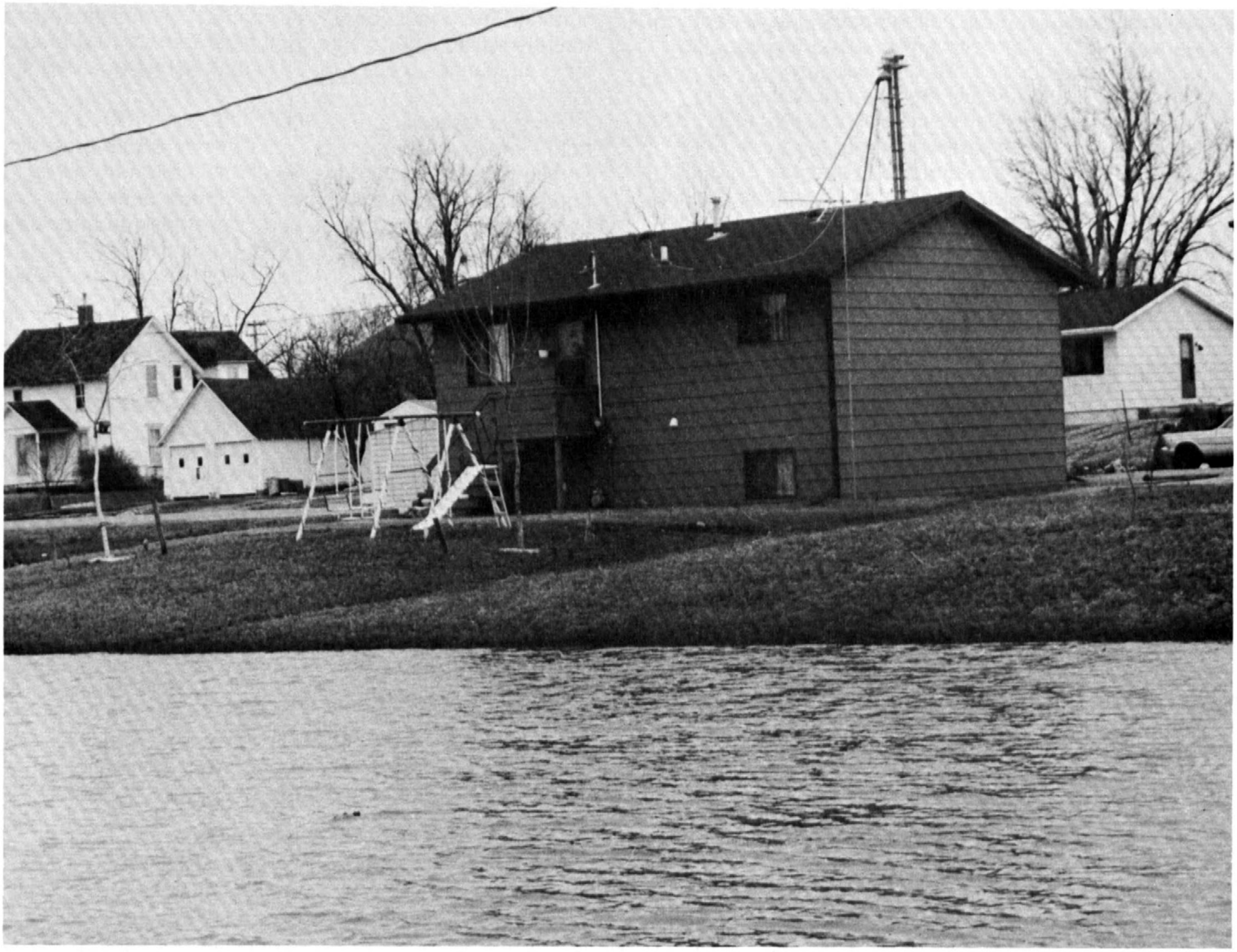


Figure 17.—Ponded water in a residential area of Okoboji soils at Colo. Large tile mains are needed to carry away storm waters.

susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding (fig. 17), shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 11 shows the degree and the kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 11 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 11 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 11 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 12 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 12, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel or stones, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water Management

Table 13 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed ponds. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones, boulders, or organic matter. A high water table affects the amount of usable material. It also affects trafficability.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, permeability of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as high content of calcium carbonate. Availability of drainage outlets is not considered in the ratings.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering Index Properties

Table 14 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil series and their morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (*1*).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 3 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

Physical and Chemical Properties

Table 15 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops.

They are extremely erodible, and vegetation is difficult to establish.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to wind erosion.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 15, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 16 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary inundation of an area, is caused by overflowing streams and by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes.

Table 16 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs, on the average, no more than once in 2 years; and *frequent* that it occurs, on the average, more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 16 are the depth to the seasonal high water table; the kind of water table—that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 16.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An *artesian* water table is under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Only saturated zones within a depth of about 6 feet are indicated. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured clayey soils that have a high water table in winter are most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*15*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 17 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Aquoll (*Aqu*, meaning water, plus *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Haplaquolls (*Hapl*, meaning minimal horizonation, plus *aquoll*, the suborder of the Mollisols that have an aquic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Haplaquolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, mesic Typic Haplaquolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the Soil Survey Manual (*14*). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (*15*). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Ankeny Series

The Ankeny series consists of well drained soils on low foot slopes, alluvial fans, and terrace positions. Permeability is moderately rapid. These soils formed in loamy and sandy alluvial and eolian materials. Native vegetation was prairie grasses. Slopes range from 2 to 5 percent.

Ankeny soils are similar to Hanlon soils and are commonly adjacent to Dickinson and Sparta soils. Hanlon soils have a thicker mollic epipedon. Dickinson and Sparta soils have a thinner surface layer and are located above Ankeny soils on the landscape.

Typical pedon of Ankeny fine sandy loam, 2 to 5 percent slopes; 1,400 feet east and 80 feet north of the southwest corner of sec. 33, T. 83 N., R. 23 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) fine sandy loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A1—8 to 22 inches; very dark brown (10YR 2/2) fine sandy loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; neutral; gradual smooth boundary.

A2—22 to 28 inches; very dark brown (10YR 2/2) fine sandy loam, very dark grayish brown (10YR 3/2) dry; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A3—28 to 36 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) fine sandy loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; very friable; neutral; gradual smooth boundary.

Bw—36 to 48 inches; brown (10YR 4/3) fine sandy loam; dark brown (10YR 3/3) coatings on faces of peds; weak medium subangular blocky structure; very friable; neutral; gradual smooth boundary.

BC—48 to 54 inches; brown (10YR 4/3) loamy fine sand; weak medium subangular blocky structure; very friable; neutral; gradual smooth boundary.

C—54 to 60 inches; dark yellowish brown (10YR 4/4) loamy fine sand; single grain; loose; slightly acid; gradual smooth boundary.

Thickness of the solum ranges from about 45 to 60 inches. Thickness of the mollic epipedon ranges from 24 to 36 inches.

The A horizon typically is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) fine sandy loam, but the range includes sandy loam. The A horizon is neutral or slightly acid. The Bw horizon ranges from dark brown (10YR 3/3) to yellowish brown (10YR 5/4). The B horizon typically is fine sandy loam but includes loamy fine sand or sand in the lower part. The Bw and BC horizons are slightly acid or neutral. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 3 to 6. The C horizon typically is loamy fine sand, but the range includes fine sandy loam to fine sand.

Biscay Series

The Biscay series consists of poorly drained soils on glacial outwash plains, valley trains, and river terraces. Permeability is moderate in the solum and rapid in the substratum. These soils formed in loamy glacial outwash underlain by calcareous, sandy and gravelly glacial till outwash. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Biscay soils are similar to Cylinder and Talcot soils and are commonly adjacent to Cylinder, Talcot, and Wadena soils. Cylinder soils are somewhat poorly drained. Talcot soils are calcareous in the surface layer. Wadena soils are well drained and are generally adjacent to, but at a higher elevation than, Biscay soils.

Typical pedon of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes; 1,700 feet west and 115 feet north of the center of sec. 14, T. 83 N., R. 24 W.

Ap—0 to 8 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A1—8 to 12 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

A2—12 to 16 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; few fine distinct dark gray (5Y 4/1) mottles; weak fine subangular blocky structure; friable; few pebbles; mildly alkaline; clear smooth boundary.

Bg1—16 to 22 inches; dark gray (5Y 4/1) clay loam; very dark gray (10YR 3/1) coatings on faces of peds; weak medium subangular blocky structure; friable; few pebbles; mildly alkaline; clear smooth boundary.

Bg2—22 to 28 inches; dark gray (5Y 4/1) clay loam; few fine distinct light olive gray (5Y 6/2) mottles; weak medium subangular blocky structure; friable; few pebbles; few fine segregations of lime; mildly alkaline; clear smooth boundary.

Bg3—28 to 33 inches; dark gray (5Y 4/1) loam; common fine distinct light olive gray (5Y 6/2) mottles; weak coarse subangular blocky structure; friable; few pebbles; moderately alkaline; abrupt smooth boundary.

2C1—33 to 38 inches; light olive brown (2.5Y 5/4) and grayish brown (2.5Y 5/2) loamy sand; single grain; loose; few pebbles; slightly effervescent; mildly alkaline; clear smooth boundary.

2C2—38 to 60 inches; light olive brown (2.5Y 5/6) gravelly loamy coarse sand; few fine distinct dusky red (2.5YR 3/2) mottles; single grain; loose; few pebbles; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to loamy sand or material of coarser texture range from 32 to 40 inches. The depth to free carbonates typically is within the same range, but a few pedons have a calcareous A1 horizon. Thickness of the mollic epipedon ranges from 16 to 24 inches.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1, or it is of neutral hue and has value of 2 or 3 and chroma of 0. The A horizon is dominantly clay loam, but the range includes loam and silty clay loam that are high in content of sand. The A horizon ranges from mildly alkaline to slightly acid. The Bg2 and Bg3 horizons have hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 or 2 with mottles of high or low chroma throughout. The Bg2 and Bg3 horizons typically are loam or silty clay loam that are high in content of sand. The Bg2 and Bg3 horizons are neutral or mildly alkaline. In some pedons, the lower part of the B horizon contains free carbonates. The C and 2C horizons have a matrix with hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 2 to 6. These horizons range from loamy sand to sand and gravel. The 2C horizon is 4 to 6 or more feet thick and overlies glacial till or finer textured overwash.

Bode Series

The Bode series consists of well drained, moderately permeable soils on uplands of low relief. These soils formed in glacial or lacustrine sediments that overlie calcareous glacial till. Native vegetation was prairie grasses. Slopes range from 2 to 5 percent.

Bode soils are similar to Clarion soils and are commonly adjacent to Kossuth and Ottosen soils. Clarion soils have lower clay content than Bode soils. Kossuth and Ottosen soils have a grayer B horizon and poorer internal drainage and are lower on the landscape.

Typical pedon of Bode clay loam, 2 to 5 percent slopes; 600 feet west and 117 feet south of the northeast corner of sec. 2, T. 85 N., R. 24 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam mixed with very dark grayish brown (10YR 3/2), very dark gray (10YR 3/1) dry; very dark gray (10YR 3/1) kneaded; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A—8 to 12 inches; very dark grayish brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

Bw1—12 to 19 inches; olive brown (2.5Y 4/4) clay loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; moderate fine subangular blocky structure; firm; neutral; gradual smooth boundary.

Bw2—19 to 24 inches; olive brown (2.5Y 4/4) clay loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine prismatic structure parting to moderate fine subangular blocky; firm; discontinuous clay films; neutral; clear smooth boundary.

Bw3—24 to 29 inches; olive brown (2.5Y 4/4) clay loam; weak fine prismatic structure parting to moderate fine subangular blocky; firm; discontinuous clay films; neutral; clear smooth boundary.

BC—29 to 34 inches; light olive brown (2.5Y 5/4) clay loam; olive brown (2.5Y 4/4) coatings on faces of peds; few fine faint yellowish brown (10YR 5/6) mottles; weak medium prismatic structure; firm; common fine calcium carbonate concretions; moderately alkaline; gradual wavy boundary.

2C—34 to 60 inches; light olive brown (2.5Y 5/4) loam; few fine faint yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) mottles; massive; friable; few pebbles; mildly alkaline.

Thickness of the solum and depth to free carbonates typically are 24 to 40 inches but range from 18 to 50 inches. Thickness of the mollic epipedon typically is 10 to 16 inches.

The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). It typically is clay loam but includes silty clay loam that is high in sand. The B horizon is brown (10YR 4/3) and dark yellowish brown (10YR 4/4) or olive brown (2.5Y 4/4). It typically is clay loam but in places is silty clay loam that is high in sand content. The solum below the plow layer typically is neutral or slightly acid. The 2C horizon typically is light olive brown (2.5Y 5/4) or grayish brown (2.5Y 5/2) with yellowish brown (10YR 5/6) mottles. It typically is loam but ranges from sandy loam to clay loam.

Canisteo Series

The Canisteo series consists of poorly drained, moderately permeable soils on uplands. These soils formed in calcareous local alluvium or glacial till. Native vegetation was water-tolerant grasses. Slopes range from 0 to 2 percent.

Canisteo soils are similar to Harps and Webster soils and are commonly adjacent to Okoboji and Webster soils. Canisteo soils are mildly alkaline in the solum, whereas Webster soils are neutral in the solum, and Harps soils are moderately alkaline in the solum. The very poorly drained Okoboji soils are in depressions.

Typical pedon of Canisteo clay loam, 0 to 2 percent slopes; 2,049 feet south and 280 feet east of the northwest corner of sec. 5, T. 82 N., R. 24 W.

Ap—0 to 10 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine granular and subangular blocky structure; friable; slightly effervescent; mildly alkaline; gradual smooth boundary.

A—10 to 15 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; slightly effervescent; mildly alkaline; gradual smooth boundary.

AB—15 to 23 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; few black (10YR 2/1) coatings on faces of peds; few fine distinct dark gray (5Y 4/1) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; few fine brown (7.5YR 4/4) oxides; slightly effervescent; mildly alkaline; gradual smooth boundary.

Bg1—23 to 29 inches; dark gray (5Y 4/1) silty clay loam; some very dark gray (5Y 3/1) coatings on faces of peds; few fine distinct olive gray (5Y 5/2) mottles and few fine prominent yellowish brown (10YR 5/8) mottles; weak medium prismatic structure parting to moderate fine subangular blocky; firm; black (10YR 2/1) fills in old root channels; few fine calcium carbonate concretions; slightly effervescent; mildly alkaline; gradual smooth boundary.

Bg2—29 to 37 inches; mixed dark gray (5Y 4/1) and olive gray (5Y 5/2) silty clay loam; few fine prominent yellowish brown (10YR 5/8) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; black (10YR 2/1) krotovina; 1- to 2-inch concretions of calcium carbonate; strongly effervescent; mildly alkaline; clear smooth boundary.

Cg1—37 to 43 inches; olive gray (5Y 5/2) and olive (5Y 5/3) clay loam; dark gray (5Y 4/1) coatings on old root channels; many fine prominent yellowish brown (10YR 5/8) mottles; weak medium subangular blocky structure; friable; few fine calcium carbonate concretions; strongly effervescent; moderately alkaline; gradual smooth boundary.

Cg2—43 to 54 inches; olive gray (5Y 5/2) loam; few fine prominent yellowish brown (10YR 5/8) mottles; massive; friable; few very fine snail shell fragments; few fine dark brown (7.5YR 4/4) oxides; calcium carbonate concretions; violently effervescent; moderately alkaline; clear smooth boundary.

Cg3—54 to 60 inches; mixed olive gray (5Y 5/2) and yellowish brown (10YR 5/4) loam; few fine prominent yellowish brown (10YR 5/8) mottles; massive; friable; iron accumulation in a few soft pipe stems about 1-1/4 inches long; few fine calcium carbonate accumulations; violently effervescent; moderately alkaline.

Thickness of the solum ranges from 20 to 40 inches. Free carbonates are in all parts of the fine earth fraction between depths of 10 and 20 inches. Thickness of the mollic epipedon ranges from 14 to 24 inches.

The A horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It ranges from silty clay loam to clay loam. The Bg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. The Bg horizon typically is silty clay loam but includes loam, clay loam, and silty clay loam. The solum typically is calcareous and mildly alkaline or moderately alkaline throughout. The Cg horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 through 4. It typically is loam or clay loam. Stratified loam, silty clay loam, and sandy loam horizons are present in some pedons.

Clarion Series

The Clarion series consists of well drained, moderately permeable soils on uplands. These soils formed in calcareous glacial till under prairie vegetation. Slopes range from 2 to 14 percent.

Clarion soils are similar to Bode and Lester soils and are commonly adjacent to Nicollet and Webster soils. Bode soils have more clay in the solum. Lester soils do not have a mollic epipedon. Nicollet soils are somewhat poorly drained and are downslope from Clarion soils. Webster soils are poorly drained and are on lower landscape positions.

Typical pedon of Clarion loam, 2 to 5 percent slopes; 1,940 feet south and 76 feet east of the northwest corner of sec. 5, T. 83 N., R. 24 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A—8 to 13 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) and brown (10YR 4/3) dry; very dark brown (10YR 2/2) and brown (10YR 4/3) coatings on faces of peds; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

BA—13 to 19 inches; brown (10YR 4/3) loam; few very dark grayish brown (10YR 3/2) and dark yellowish brown (10YR 4/4) coatings on faces of peds; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

Bw—19 to 25 inches; brown (10YR 4/3) loam; dark brown (10YR 3/3) coatings on faces of peds; weak medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

BC—25 to 33 inches; dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; friable; neutral; gradual smooth boundary.

C—33 to 60 inches; light olive brown (2.5Y 5/4) loam; common fine distinct brown (7.5YR 4/4) mottles; massive; friable; light gray (10YR 7/2) lime accumulations; moderately alkaline.

Thickness of the solum and depth to free carbonates typically are 25 to 40 inches but range from 18 to 50 inches. Thickness of the mollic epipedon typically is 10 to 17 inches.

The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). It typically is loam but includes silt loam that is high in sand content. The B horizon is brown (10YR 4/3) and dark yellowish brown (10YR 4/4). It typically is loam or clay loam but in places is sandy loam. The solum below the plow layer typically is neutral or slightly acid. The C horizon typically is yellowish brown (10YR 5/4) or light olive brown (2.5Y 5/4). It typically is loam but ranges from sandy loam to clay loam.

The Clarion soils in map units 138C2, 638C2, and 638D2 are taxadjuncts to the series because they have a slightly thinner surface layer than is defined for the series.

Coland Series

The Coland series consists of poorly drained, moderately permeable soils on bottom lands and in some upland drainageways. These soils formed in loamy alluvium. Slopes range from 0 to 2 percent.

Coland soils are similar to Spillville soils and are commonly adjacent to Spillville, Terril, and Zook soils. Where Coland and Spillville soils are associated on a bottom land, the Coland soils are commonly farther from the stream channel. The Coland and Zook soils are more poorly drained and contain more clay than the Spillville soils. In upland drainageways, the Coland soils are commonly adjacent to the moderately well drained Terril soils.

Typical pedon of Coland clay loam, 0 to 2 percent slopes; 250 feet west and 50 feet north of the southeast corner of section 32, T. 83 N., R. 23 W.

Ap—0 to 8 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak medium granular structure; friable; neutral; abrupt smooth boundary.

A1—8 to 16 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure; firm; neutral; gradual smooth boundary.

A2—16 to 28 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure; firm; neutral; gradual smooth boundary.

A3—28 to 38 inches; black (10YR 2/1) clay loam, very dark grayish brown (10YR 3/2) dry; weak fine subangular blocky structure; firm; neutral; gradual smooth boundary.

AC—38 to 47 inches; very dark gray (10YR 3/1) clay loam; few fine faint grayish brown (2.5Y 5/2) and strong brown (7.5YR 5/6) mottles; weak medium prismatic structure parting to weak medium subangular blocky; firm; neutral; gradual smooth boundary.

C—47 to 60 inches; olive gray (5Y 5/2) clay loam; common fine distinct strong brown (7.5YR 5/6) mottles; massive; firm; dark olive gray (5Y 3/2) fills in channels; black (N 2/0) krotovina below a depth of 55 inches; neutral.

Thickness of the solum ranges from 36 to 48 inches. Thickness of the mollic epipedon ranges from 40 to more than 60 inches.

The A horizon typically is black (N 2/0 or 10YR 2/1) but includes very dark gray (10YR 3/1 to 5Y 3/1) in the lower part. It typically is clay loam or silty clay loam that is high in sand, but it includes loam in the upper 10 inches. The solum is neutral or slightly acid. The C horizon ranges from sandy loam to clay loam but includes thin strata ranging from silty clay to loamy sand.

Cordova Series

The Cordova series consists of poorly drained soils on uplands. Permeability is moderately slow. These soils formed in glacial till and in local alluvium derived from till. Native vegetation was dominantly prairie grasses and trees. Slopes range from 0 to 2 percent.

Cordova soils are similar to Nicollet and Webster soils and are commonly adjacent to Hayden and Lester soils. Nicollet soils are somewhat poorly drained and have a browner B horizon. Nicollet and Webster soils have less clay in the B horizon. Hayden and Lester soils are better drained and are upslope from Cordova soils.

Typical pedon of Cordova clay loam, 0 to 2 percent slopes; 100 feet east and 2,440 feet north of the southwest corner of sec. 36, T. 82 N., R. 21 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A—8 to 13 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to moderate fine granular; friable; slightly acid; clear smooth boundary.

Bt1—13 to 20 inches; very dark gray (10YR 3/1) clay loam; nearly continuous black (10YR 2/1) coatings on faces of peds; few fine distinct dark grayish brown (2.5Y 4/2) mottles; moderate fine subangular blocky structure; friable; few fine prominent strong brown (7.5YR 5/6) oxides; neutral; clear smooth boundary.

Btg1—20 to 23 inches; olive gray (5Y 5/2) clay loam; nearly continuous very dark gray (10YR 3/1) coatings on faces of peds; few fine prominent strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure parting to moderate fine subangular blocky; firm; neutral; clear smooth boundary.

Btg2—23 to 29 inches; olive gray (5Y 5/2) clay loam; nearly continuous very dark gray (10YR 3/1) coatings on prisms; moderate fine prismatic structure parting to moderate fine angular blocky; firm; neutral; clear smooth boundary.

Btg3—29 to 35 inches; olive gray (5Y 5/2) clay loam; nearly continuous very dark gray (10YR 3/1) coatings on prisms and in root channels; common fine prominent strong brown (7.5YR 5/6) mottles; moderate fine prismatic structure parting to weak medium subangular blocky; firm; few manganese concretions; neutral; gradual smooth boundary.

BCg—35 to 41 inches; olive gray (5Y 5/2) clay loam; very dark gray (10YR 3/1) organic fills in root channels and discontinuous coatings on prisms; common fine prismatic strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure; firm; few manganese concretions; light gray (10YR 7/1) lime concretions; mildly alkaline; clear wavy boundary.

Cg—41 to 60 inches; olive gray (5Y 5/2) loam; few very dark gray (10YR 3/1) fills in old tree root channels; common medium prominent strong brown (10YR 5/6) mottles; massive; friable; light gray (10YR 7/1) lime concretions; strongly effervescent; mildly alkaline.

Thickness of the solum ranges from 24 to 50 inches. The depth to free carbonates has about the same range, but in many pedons the BCg horizon contains free carbonates. The mollic epipedon ranges from 14 to 24 inches.

The Ap and A horizons are black (10YR 2/1 or N 2/0) or very dark gray (10YR 3/1). They are clay loam or silty clay loam that is high in sand content. The A horizon is neutral or slightly acid. The upper part of the Bt horizon has hue of 10YR through 5Y and value of 3 through 5. Chroma is 1 if hue is 10YR and 1 or 2 if hue is 2.5Y or 5Y. The lower part of the Bt horizon has hue of 5Y and 2.5Y, value of 4 or 5, and chroma of 1 or 2. The B horizon typically is clay loam, but strata of silty clay loam is within the range. The BCg horizon is clay loam. The Bt horizon is neutral through medium acid. The Cg horizon has hue of 5Y or 2.5Y, value of 5 or 6, and chroma of 2 to 4. It is loam or clay loam and is mildly alkaline or moderately alkaline.

Cylinder Series

The Cylinder series consists of somewhat poorly drained soils mainly on terraces along the larger rivers and streams. These soils formed in loamy alluvium underlain by sand and gravel. Permeability is moderate in the solum and very rapid in the substratum. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Cylinder soils are similar to Biscay soils and are commonly adjacent to Biscay and Wadena soils. Biscay soils are poorly drained, have a grayer B horizon, and are in similar landscape positions. Wadena soils are well drained, have a browner B horizon, and are at higher elevations.

Typical pedon of Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes; 380 feet west and 430 feet south of the center of sec. 14, T. 83. N., R. 24 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A—8 to 13 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; few black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

BA—13 to 18 inches; dark grayish brown (10YR 4/2) loam; few very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

Bw—18 to 22 inches; dark grayish brown (10YR 4/2) loam; few fine faint brown (10YR 5/3) mottles; weak medium subangular blocky structure; friable; few pebbles; neutral; gradual smooth boundary.

BC—22 to 27 inches; dark grayish brown (2.5Y 4/2) sandy clay loam; few fine faint light olive brown (2.5Y 5/4) mottles; weak medium subangular blocky structure; friable; few pebbles; neutral; clear smooth boundary.

2C1—27 to 33 inches; light olive brown (2.5Y 5/4) gravelly loamy coarse sand; few fine prominent yellowish brown (10YR 5/8) mottles; single grain; loose; few pebbles; neutral; gradual smooth boundary.

2C2—33 to 40 inches; mixed light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/8) gravelly coarse sand; single grain; loose; few pebbles; neutral; gradual smooth boundary.

2C3—40 to 60 inches; light olive brown (2.5Y 5/4) coarse sand and gravel; single grain; loose; moderately alkaline; strongly effervescent.

Thickness of the solum ranges from 24 to 48 inches. Depth to sand and gravel ranges from 24 to 40 inches.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), and very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) and is 10 to 24 inches thick. The B horizon is generally dark grayish brown (2.5Y 4/2), but it ranges to very dark gray (10YR 3/1) or very dark grayish brown (2.5Y 3/2 or 10YR 3/2) in the upper part and to grayish brown (2.5Y 5/2), olive brown (2.5Y 4/4), or light olive brown (2.5Y 5/4) in the lower part. It is mottled yellowish brown or olive brown in places. The B horizon is loam or clay loam that in most places grades to sandy clay loam, loam, or sandy loam in the lower part. In a few places, the 2C horizon is loamy sand or sand without much gravel. It is generally calcareous, but in places the upper few inches is leached. The A horizon and the upper part of the B horizon are generally neutral or slightly acid grading to neutral as depth increases. The A horizon ranges to medium acid in places. The 2C horizon is mainly mildly alkaline or moderately alkaline and calcareous, although in places it is neutral and is noncalcareous in a few inches of the upper part.

Dickinson Series

The Dickinson series consists of somewhat excessively drained soils on uplands and stream terraces. These soils formed in glacial till sediment reworked by wind. Permeability is moderately rapid in the upper part of the profile and rapid in the lower part. Slopes range from 0 to 9 percent.

Dickinson soils are commonly adjacent to Sparta soils. Sparta soils have more sand and less clay in the solum than Dickinson soils.

Typical pedon of Dickinson fine sandy loam, 2 to 5 percent slopes; 115 feet north and 2,400 feet west of the southeast corner of sec. 29, T. 83 N., R. 23 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; very friable; medium acid; abrupt smooth boundary.

A—8 to 17 inches; very dark brown (10YR 2/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; weak coarse subangular blocky structure parting to weak fine granular; very friable; neutral; gradual smooth boundary.

BA—17 to 24 inches; very dark grayish brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; very friable; neutral; clear smooth boundary.

Bw—24 to 33 inches; brown (10YR 4/3) fine sandy loam; continuous dark brown (10YR 3/3) coatings; weak medium subangular blocky structure; very friable; neutral; clear smooth boundary.

BC—33 to 40 inches; dark yellowish brown (10YR 4/4) loamy fine sand; weak coarse subangular blocky structure; very friable; neutral; gradual smooth boundary.

C—40 to 60 inches; yellowish brown (10YR 5/4) sand; single grain; loose; neutral.

Depth to loamy sand or sand ranges from 24 to 36 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 to 3. It typically is fine sandy loam but includes sandy loam. The A horizon is neutral to medium acid. The Bw horizon has hue of 10YR, value of 3 to 5, and chroma of 3 to 6. The upper part of the B horizon typically is sandy loam or fine sandy loam grading to loamy fine sand, loamy sand, and sand in the lower part of the horizon. The B horizon is neutral to strongly acid. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 3 to 6. It ranges from loamy fine sand to sand.

Estherville Series

The Estherville series consists of somewhat excessively drained soils on stream terraces. These soils formed in glacial outwash sediment. Permeability is moderately rapid in the solum and rapid in the substratum. Native vegetation was prairie grasses. Slopes range from 2 to 9 percent.

Estherville soils are similar to Flagler soils and are commonly adjacent to Flagler and Wadena soils. Flagler soils contain less gravel and are leached to a greater depth. Wadena soils have a thicker solum and contain more clay in the upper part.

Typical pedon of Estherville sandy loam, 2 to 9 percent slopes; 900 feet east and 500 feet north of the center of sec. 14, T. 38 N., R. 24 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) sandy loam mixed with dark brown (10YR 3/3), dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; about 5 percent gravel; slightly acid; abrupt smooth boundary.

Bw—9 to 12 inches; dark yellowish brown (10YR 4/4) sandy loam; few brown (10YR 4/3) coatings on faces of peds; weak medium subangular blocky structure; friable; 7 percent gravel; neutral; gradual smooth boundary.

BC—12 to 16 inches; brown (7.5YR 4/4) sandy loam; brown (10YR 4/3) coatings on faces of peds; weak coarse subangular blocky structure; very friable; 10 percent gravel; neutral; gradual smooth boundary.

2C1—16 to 20 inches; brown (7.5YR 4/4) gravelly coarse sand; single grain; loose; mildly alkaline; gradual smooth boundary.

2C2—20 to 31 inches; brown (10YR 4/3) sand and gravel; single grain; loose; slightly effervescent; mildly alkaline; gradual smooth boundary.

2C3—31 to 60 inches; mixed light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/8) sand and gravel; single grain; loose; slightly effervescent; moderately alkaline.

Thickness of the solum and depth to the 2C horizon are 15 to 30 inches. This is the same as the depth to free carbonates. Thickness of the mollic epipedon ranges from 8 to 18 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is sandy loam or loam and is neutral through medium acid. The Bw horizon has hue of 10YR, value of 3 or 4, and chroma of 3 or 4. It is coarse sandy loam, sandy loam, or coarse loam and is medium acid through neutral. The upper part of the 2C horizon has hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 3 or 4. The lower part of the 2C horizon is mottled grayish brown (10YR 5/2) through light yellowish brown (10YR 5/6). The 2C horizon is coarse sand or sand and gravel. The 2C horizon typically is calcareous throughout, but the upper few inches is leached in some pedons.

Farrar Series

The Farrar series consists of well drained soils on uplands. These soils formed in eolian material over loamy glacial till. Permeability is moderately rapid in the upper part of the profile and moderate in the lower part. Native vegetation was prairie grasses. Slopes range from 2 to 5 percent..

Farrar soils are similar to Dickinson soils and are commonly adjacent to Clarion and Dickinson soils. Farrar soils are well drained whereas Dickinson soils are well drained to somewhat excessively drained. Clarion soils have more clay and less sand in the surface layer and are on similar landscape positions. Dickinson soils are on uplands at higher elevations.

Typical pedon of Farrar fine sandy loam, 2 to 5 percent slopes; 2,140 feet north and 45 feet west of the southeast corner of sec. 34, T. 83 N., R. 23 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; weak medium granular structure; very friable; common roots; slightly acid; abrupt smooth boundary.

A—7 to 14 inches; very dark brown (10YR 2/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; very dark grayish brown (10YR 3/2) crushed; weak medium granular structure; very friable; common roots; slightly acid; clear smooth boundary.

BA—14 to 20 inches; brown (10YR 4/3) fine sandy loam; very dark grayish brown (10YR 3/2) in root channels; weak medium subangular blocky structure; very friable; common roots; slightly acid; gradual smooth boundary.

2Bw1—20 to 29 inches; dark yellowish brown (10YR 4/4) loam; moderate medium subangular blocky structure; friable; common roots; common coarse sand grains; neutral; gradual smooth boundary.

2Bw2—29 to 39 inches; yellowish brown (10YR 5/4) loam; few fine distinct strong brown (7.5YR 5/6) oxides; moderate medium subangular blocky structure; friable; common roots; common coarse sand grains; neutral; clear wavy boundary.

2C—39 to 60 inches; light yellowish brown (10YR 6/4) loam, few fine distinct strong brown (7.5YR 5/6) oxides; massive; friable; roots to a depth of 52 inches; moderately alkaline; strongly effervescent.

Thickness of the solum and depth to free carbonates typically are 24 to 40 inches. Thickness of the eolian material ranges from 18 to 36 inches. Thickness of the mollic epipedon typically is 12 to 19 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The A horizon typically is fine sandy loam but the range includes sandy loam. The BA horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 3 or 4. It is commonly fine sandy loam but thin layers of loamy fine sand are in the range. The underlying loamy till has hue of 10YR, value of 3 or 4, and chroma of 4 or 5. The 2C horizon has hue of 10YR or 2.5Y, value of 4 through 6, and chroma of 4. Mottles with chroma of 2 to 8 are below a depth of 30 inches in places.

Flagler Series

The Flagler series consists of somewhat excessively drained soils formed in loamy glacial outwash over sandy sediments on stream terraces and outwash areas on uplands. Permeability is moderately rapid in the upper part of the profile and very rapid in the lower part. Native vegetation was prairie grasses. Slopes range from 0 to 5 percent.

Flagler soils are similar to the Estherville soils and are commonly adjacent to Estherville and Wadena soils. Estherville soils contain more gravel and are calcareous at a shallower depth. Wadena soils have more clay and less sand in the surface layer and subsoil and occur in similar landscape positions.

Typical pedon of Flagler sandy loam, 0 to 2 percent slopes; 1,800 feet west and 33 feet south of the northeast corner of sec. 19, T. 85 N., R. 23 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) sandy loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A1—8 to 14 inches; very dark brown (10YR 2/2) sandy loam, very dark grayish brown (10YR 3/2) dry; weak medium subangular blocky structure; friable; neutral; clear smooth boundary.

A2—14 to 21 inches; very dark grayish brown (10YR 3/2) sandy loam mixed with some dark brown (10YR 3/3), dark grayish brown (10YR 4/2) dry; weak medium subangular blocky structure; friable; neutral; gradual smooth boundary.

BA—21 to 27 inches; brown (10YR 4/3) sandy loam; dark brown (10YR 3/3) coatings on faces of peds; weak medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

Bw—27 to 32 inches; brown (10YR 4/3) sandy loam; few dark brown (10YR 3/3) coatings on faces of peds; weak medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

BC—32 to 39 inches; dark yellowish brown (10YR 4/4) loamy sand; brown (10YR 4/3) coatings on faces of peds; weak medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

C1—39 to 50 inches; dark yellowish brown (10YR 4/4) loamy sand; single grain; loose; few pebbles; slightly acid; gradual smooth boundary.

2C2—50 to 60 inches; mixed dark yellowish brown (10YR 4/4) and brown (10YR 4/3) gravelly sand; single grain; loose; slightly acid.

Thickness of the solum typically is 24 to 40 inches. Depth to free carbonates typically is more than 5 feet. Thickness of the mollic epipedon ranges from 10 to 24 inches.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2) sandy loam or fine sandy loam. The A1 horizon is neutral or slightly acid. The Bw horizon has hue of 10YR or 7.5YR, value of 3 through 5, and chroma of 2 through 6. The B horizon typically is sandy loam but includes loamy sand. It ranges from slightly acid to strongly acid. The 2C horizon has hue of 10YR, value of 4 or 5, and chroma of 3 through 6. It ranges from loamy sand to gravelly sand. The 2C horizon is slightly acid or medium acid.

Hanlon Series

The Hanlon series consists of moderately well drained soils on natural levees along streams. Permeability is moderately rapid. These soils formed in loamy alluvium under a native vegetation of prairie grasses. Slopes range from 0 to 2 percent.

Hanlon soils are similar to Ankeny soils and are commonly adjacent to Coland and Spillville soils. Ankeny soils have a thinner mollic epipedon. Coland soils are poorly drained and have more clay and less sand than Hanlon soils. Spillville soils are moderately well drained and have less sand than Hanlon soils. Both Coland and Spillville soils occur in similar landscape positions.

Typical pedon of Hanlon fine sandy loam, 0 to 2 percent slopes; 775 feet south and 480 feet west of the northeast corner of sec. 14, T. 83 N., R. 24 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) fine sandy loam, dark gray (10YR 4/1) dry; weak medium granular structure; very friable; slightly acid; abrupt smooth boundary.

A1—8 to 18 inches; very dark brown (10YR 2/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; very friable; neutral; clear smooth boundary.

A2—18 to 33 inches; very dark grayish brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; very friable; very dark brown (10YR 2/2) coatings in root channels; neutral; clear smooth boundary.

A3—33 to 39 inches; very dark grayish brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; very friable; very dark brown (10YR 2/2) coatings in root channels; neutral; clear smooth boundary.

Bw—39 to 48 inches; very dark grayish brown (10YR 3/2) fine sandy loam; very dark brown (10YR 2/2) coatings on peds; few fine distinct strong brown (7.5YR 5/6) mottles; weak medium subangular blocky structure; very friable; neutral; clear smooth boundary.

C—48 to 60 inches; dark grayish brown (10YR 4/2) loamy sand; few fine distinct strong brown (7.5YR 5/6) mottles; single grain; loose; neutral.

Thickness of the solum typically is 40 to more than 60 inches. Free carbonates typically do not occur to a depth of 4 feet or more. Thickness of the mollic epipedon typically is 40 to 72 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It typically is fine sandy loam but in some pedons is sandy loam. The Bw horizon, where present, has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. The Bw horizon typically is fine sandy loam but includes sandy loam. The solum typically is neutral or slightly acid. The C horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2. It ranges from loamy sand to loam.

Harps Series

The Harps series consists of poorly drained, moderately permeable, strongly calcareous soils on rims and low ridges around and between depressions in uplands. These soils formed in local alluvium derived from glacial till under native vegetation of water-tolerant grasses. Slopes range from 1 to 3 percent.

Harps soils are similar to Canisteo soils and are commonly adjacent to Canisteo and Okoboji soils on the landscape. Canisteo soils are mildly alkaline and do not have free carbonates in the surface layer. Okoboji soils are in depressions and contain less carbonates in the surface layer.

Typical pedon of Harps loam, 1 to 3 percent slopes; 600 feet west of the southeast corner of sec. 20, T. 82 N., R. 24 W.

Akp—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; moderate fine granular structure; friable; few snail shell fragments; violently effervescent; moderately alkaline; abrupt smooth boundary.

Ak1—8 to 16 inches; very dark gray (10YR 3/1) clay loam, gray (5Y 5/1) dry; moderate very fine subangular blocky structure; friable; few very fine snail shell fragments; violently effervescent; moderately alkaline; clear smooth boundary.

Ak2—16 to 20 inches; very dark gray (5Y 3/1) clay loam, gray (5Y 5/1) dry; few fine distinct olive (5Y 5/6) mottles; weak fine subangular blocky structure; friable; few pebbles; few very fine snail shell fragments; violently effervescent; moderately alkaline; clear smooth boundary.

Bkg—20 to 31 inches; olive gray (5Y 5/2) loam, light gray (5Y 7/2) dry; common fine distinct olive (5Y 5/6) mottles; few fine distinct strong brown (7.5YR 5/6) oxides; weak coarse subangular blocky structure; friable; common white (10YR 8/1) lime accumulations; violently effervescent; moderately alkaline; gradual smooth boundary.

BCkg—31 to 41 inches; light olive gray (5Y 6/2) loam; common fine distinct olive (5Y 5/6) mottles; weak medium subangular blocky structure; friable; few white (10YR 8/1) lime accumulations; violently effervescent; moderately alkaline; gradual smooth boundary.

Cg—41 to 60 inches; light olive gray (5Y 6/2) loam; common fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; violently effervescent; moderately alkaline.

Thickness of the solum ranges from 30 to 50 inches. Thickness of the mollic epipedon ranges from 10 to 20 inches.

The Akp horizon is black (10YR 2/1) or very dark gray (10YR 3/1 or N 3/0) moist and dark gray (10YR 4/1) or gray (10YR 5/1) dry. It is loam or clay loam containing 20 to 32 percent clay. The B horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. The B horizon is loam, clay loam, or sandy clay loam containing 18 to 30 percent clay. The Cg horizon typically is loam but in places is sandy clay loam. The solum is moderately alkaline.

Hayden Series

The Hayden series consists of well drained, moderately permeable soils on glacial till uplands. These soils formed in calcareous glacial till under forest vegetation. Slopes are short and range from 2 to 35 percent.

Hayden soils are similar to Lester soils and are commonly adjacent to Cordova and Lester soils. Lester soils have a darker surface layer. Cordova soils are poorly drained and have a grayer B horizon.

Typical pedon of Hayden loam, 5 to 9 percent slopes; 380 feet north and 400 feet west of the southeast corner of sec. 35, T. 82 N., R. 21 W.

A—0 to 3 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; friable; slightly acid; clear smooth boundary.

E—3 to 8 inches; dark grayish brown (10YR 4/2) loam, light brownish gray (10YR 6/2) dry; continuous very dark grayish brown (10YR 3/2) coatings on faces of peds; weak thin platy structure parting to moderate medium granular; friable; medium acid; clear smooth boundary.

BE—8 to 12 inches; brown (10YR 4/3) loam; common dark grayish brown (10YR 4/2) coatings on faces of peds; moderate fine and very fine angular blocky structure; friable; very dark grayish brown (10YR 3/2) organic fills in root channels; slightly acid; clear smooth boundary.

Bt1—12 to 18 inches; dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; friable; very dark grayish brown (10YR 3/2) fills in root channels; thin continuous clay films; slightly acid; gradual smooth boundary.

Bt2—18 to 27 inches; yellowish brown (10YR 5/4) clay loam; dark yellowish brown (10YR 4/4) coatings on faces of peds; moderate fine angular blocky structure; friable; few small (less than 1 centimeter) pebbles; thin continuous clay films; slightly acid; gradual smooth boundary.

Bt3—27 to 36 inches; yellowish brown (10YR 5/4) clay loam; weak fine prismatic structure parting to fine and medium angular blocky; friable; thin continuous clay films; slightly acid; gradual smooth boundary.

Bt4—36 to 42 inches; yellowish brown (10YR 5/4) clay loam; dark yellowish brown (10YR 4/4) coatings on faces of peds; friable; medium acid; gradual smooth boundary.

BC—42 to 53 inches; yellowish brown (10YR 5/4) loam; few dark yellowish brown (10YR 4/4) coatings on faces of peds; weak medium prismatic structure; friable; medium acid; gradual smooth boundary.

C—53 to 60 inches; yellowish brown (10YR 5/4) loam; few fine distinct brown (7.5YR 4/4) mottles; massive; friable; few iron and manganese oxide accumulations; moderately alkaline; slightly effervescent.

Thickness of the solum and depth to free carbonates typically are 30 to 55 inches but range from 24 to 60 inches. The surface layer typically is not mollic in the plow layer, but the A horizon has 1 to 5 inches of mollic colors.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The E horizon has hue of 10YR, value of 4 or 5, and chroma of 1 or 2. The A horizon typically is loam, but sandy loam and fine sandy loam are in the range. The A horizon is medium acid to neutral. The B horizon has hue of 10YR in the upper part and 10YR or 2.5Y in the lower part, value of 4 or 5, and chroma of 3 through 5. It typically is clay loam or loam, but sandy clay loam, sandy loam, or fine sandy loam are in parts of some pedons. The B horizon ranges from medium acid to strongly acid in the most acid part. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 through 6. It typically is loam, but fine sandy loam or sandy loam are within the range.

Kossuth Series

The Kossuth series consists of poorly drained soils on uplands. Permeability is moderately slow in the solum and moderate in the substratum. These soils formed in glacial or lacustrine sediment over glacial till. Slopes range from 0 to 2 percent.

Kossuth soils are similar to Webster soils and are commonly adjacent to Bode and Ottosen soils. Kossuth soils have more clay in the surface layer and subsoil than Webster soils. Bode soils are higher on the landscape, have better internal drainage, and have a browner B horizon. Kossuth soils are poorly drained whereas Ottosen soils are somewhat poorly drained.

Typical pedon of Kossuth silty clay loam, 0 to 2 percent slopes; 81 feet south and 2,060 feet east of the northwest corner of sec. 15, T. 85 N., R. 24 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A1—8 to 13 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine granular structure; firm; neutral; gradual smooth boundary.

A2—13 to 22 inches; very dark gray (N 3/0) silty clay loam, dark gray (10YR 4/1) dry; moderate very fine subangular blocky structure; firm; neutral; gradual smooth boundary.

Bg1—22 to 29 inches; dark gray (5Y 4/1) silty clay loam; very dark gray (5Y 3/1) continuous coatings on faces of peds; few fine faint olive gray (5Y 5/2) mottles; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; neutral; gradual smooth boundary.

Bg2—29 to 35 inches; olive gray (5Y 5/2) clay loam; very dark gray (5Y 3/1) coatings on faces of peds; few fine distinct yellowish brown (10YR 5/6) mottles; weak fine prismatic structure parting to moderate fine subangular blocky; firm; very dark gray (5Y 3/1) fills in root channels; neutral; gradual smooth boundary.

2C—35 to 60 inches; grayish brown (2.5Y 5/2) loam; few fine faint light olive brown (2.5Y 5/6) mottles; massive; friable; few iron and manganese concretions and common calcium carbonate concretions; moderately alkaline; strongly effervescent.

Thickness of the solum typically is 30 to 48 inches. The depth to free carbonates has about the same range as solum thickness. Thickness of the mollic epipedon typically is 20 to 24 inches.

The Ap and A1 horizons are black (N 2/0 or 10YR 2/1). The A horizon typically is silty clay loam, but thin horizons of silty clay are within the range. The A horizon is slightly acid or neutral. The Bg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. The Bg horizon is silty clay loam, clay loam, or silty clay. It is slightly acid or neutral. The 2C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2 with mottles of higher chroma. The 2C horizon is neutral to moderately alkaline.

Lester Series

The Lester series consists of well drained, moderately permeable soils on uplands. These soils formed in calcareous glacial till under native vegetation of mixed hardwood forest and prairie grasses. Slopes are short and range from 2 to 25 percent.

Lester soils are similar to Clarion and Hayden soils and are commonly adjacent to Clarion, Hayden, Nicollet, and Storden soils. Clarion soils have a thicker, darker A horizon. Hayden soils have a thinner A horizon. Nicollet soils are somewhat poorly drained and are downslope from Lester soils. Storden soils have carbonates throughout.

Typical pedon of Lester loam, 5 to 9 percent slopes; 60 feet west and 880 feet south of the northeast corner of sec. 2, T. 82 N., R. 24 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; common roots; few pebbles; slightly acid; abrupt smooth boundary.

E—8 to 11 inches; dark grayish brown (10YR 4/2) loam, light gray (10YR 7/2) coatings dry; weak thick platy structure parting to moderate medium angular blocky; friable; common roots; few pebbles; medium acid; abrupt smooth boundary.

BE—11 to 17 inches; brown (10YR 4/3) loam, pale brown (10YR 6/3) coatings dry; dark grayish brown (10YR 4/2) coatings on faces of peds; moderate fine subangular blocky structure; friable; common roots; few pebbles; strongly acid; clear smooth boundary.

Bt1—17 to 24 inches; brown (10YR 4/3) clay loam; moderate fine and medium subangular blocky structure; friable; common roots; nearly continuous dark brown (10YR 3/3) clay films; few pebbles; strongly acid; clear smooth boundary.

Bt2—24 to 30 inches; dark yellowish brown (10YR 4/4) clay loam; few very dark gray (10YR 3/1) coatings in root channels; few fine faint strong brown (7.5YR 5/6) oxides; weak medium subangular blocky structure; friable; few roots; few thin discontinuous dark brown (10YR 3/3) clay films; few pebbles; slightly acid; clear smooth boundary.

Bt3—30 to 35 inches; dark yellowish brown (10YR 4/4) clay loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; few roots; thick continuous very dark gray (10YR 3/1) clay films on prism faces; few pebbles; mildly alkaline; abrupt wavy boundary.

C—35 to 60 inches; light olive brown (2.5Y 5/4) loam; massive; friable; few roots; few pebbles; strongly effervescent; moderately alkaline.

Thickness of the solum and depth to free carbonates typically are 30 to 40 inches but range from 20 to 54 inches. The surface layer typically has mollic colors to a plow layer depth of about 8 inches.

The Ap or A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It typically is loam, but in places it is silt loam high in content of sand. If an E horizon is present, it is brown (10YR 4/3) or dark grayish brown (10YR 4/2) loam. The A horizon is medium acid or slightly acid. The upper part of the B horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4). The lower part of the B horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 or 4. The B horizon is loam or clay loam. The upper part of the B horizon ranges from slightly acid to strongly acid. The C horizon has hue of 2.5Y, value of 4 to 6, and chroma of 3 to 6. It typically is loam but ranges from sandy loam to clay loam.

Lindley Series

The Lindley series consists of well drained soils on uplands. Permeability is moderately slow. These soils formed in glacial till under forest vegetation. Slopes range from 18 to 25 percent.

Lindley soils are similar to and are commonly adjacent to Hayden soils. Lindley soils are generally leached to a greater depth and have more clay in the B horizon than the Hayden soils. Hayden soils are above the Lindley soils on the landscape.

Typical pedon of Lindley loam, 18 to 25 percent slopes; 320 feet north and 800 feet west of the southeast corner of sec. 35, T. 82 N., R. 21 W.

A—0 to 3 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; friable; slightly acid; abrupt smooth boundary.

E1—3 to 6 inches; dark grayish brown (10YR 4/2) loam, light brownish gray (10YR 6/2) dry; weak medium prismatic structure parting to moderate fine granular; friable; slightly acid; abrupt smooth boundary.

E2—6 to 11 inches; brown (10YR 5/3) loam; very dark grayish brown (10YR 3/2) organic fills in pores; weak medium platy structure parting to moderate fine granular; friable; medium acid; clear smooth boundary.

BE—11 to 14 inches; brown (10YR 4/3) light clay loam; moderate fine subangular blocky structure; friable; medium acid; clear smooth boundary.

Bt1—14 to 22 inches; brown (10YR 4/3) clay loam; moderate fine angular blocky structure; firm; strongly acid; clear smooth boundary.

Bt2—22 to 27 inches; dark yellowish brown (10YR 4/4) clay loam; common fine distinct strong brown (7.5YR 5/6) mottles; weak fine prismatic structure parting to moderate fine angular blocky; firm; strongly acid; gradual smooth boundary.

BC—27 to 41 inches; yellowish brown (10YR 5/6) clay loam; common fine distinct strong brown (7.5YR 5/8) mottles; weak medium prismatic structure; firm; medium acid; gradual smooth boundary.

C—41 to 60 inches; mottled strong brown (7.5YR 5/6) and light yellowish brown (2.5Y 6/4) clay loam; dark grayish brown (10YR 4/2) coatings on prisms and root channels; weak coarse prismatic structure; friable; neutral.

Thickness of the solum ranges from 30 to about 50 inches. The A horizon has 1 to 5 inches of mollic colors.

The A horizon has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. The E horizon has hue of 10YR, value of 3 through 6, and chroma of 2 through 4. Typically, the A horizon is loam, but in some pedons it is silt loam or clay loam. The A horizon is slightly acid or medium acid. The Bt horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 3 through 6. In some pedons, the lower part of the Bt horizon is mottled. The Bt horizon is clay loam or loam and ranges from strongly acid through slightly acid. The C horizon is yellowish brown (10YR 5/6) or strong brown (7.5YR 5/6) and typically is mottled with gray hues and lower chroma. The C horizon is loam or clay loam. It is neutral or slightly acid.

Nicollet Series

The Nicollet series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils are on low ridges and on plane to slightly concave side slopes. Nicollet soils formed in loamy glacial till. Slopes range from 1 to 3 percent.

Nicollet soils are similar to Cordova and Ottosen soils and are commonly adjacent to Canisteo, Clarion, and Webster soils. Cordova, Canisteo, and Webster soils have a grayer B horizon and poorer internal drainage. Ottosen soils have more clay in the solum. Canisteo soils have a calcareous A horizon. Clarion soils have a browner B horizon and better internal drainage than Nicollet soils.

Typical pedon of Nicollet loam, 1 to 3 percent slopes; 490 feet south and 326 feet west of the northeast corner of sec. 29, T. 82 N., R. 24 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A—8 to 17 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure; friable; few manganese concretions; neutral; gradual smooth boundary.

BA—17 to 23 inches; dark grayish brown (10YR 4/2) clay loam; very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure; friable; few manganese concretions; neutral; gradual smooth boundary.

Bw—23 to 29 inches; dark grayish brown (2.5Y 4/2) clay loam; common medium distinct light yellowish brown (2.5Y 6/4) and few fine prominent strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure; friable; few fine pebbles; few manganese concretions; neutral; gradual smooth boundary.

BC—29 to 36 inches; light yellowish brown (2.5Y 6/4) loam; dark grayish brown (2.5Y 4/2) coatings on faces of peds; common fine prominent strong brown (7.5YR 5/6) mottles; few fine prominent dark reddish brown (5YR 3/2) oxides; weak fine subangular blocky structure; friable; few lime accumulations; few manganese concretions; slightly effervescent; mildly alkaline; gradual smooth boundary.

C—36 to 60 inches; grayish brown (2.5Y 5/2) loam; many fine prominent strong brown (7.5YR 5/6) mottles; few fine prominent dark reddish brown (5YR 3/2) oxides; massive; friable; many lime accumulations; few manganese concretions; strongly effervescent; moderately alkaline.

Thickness of the solum and depth to carbonates typically are 30 to 36 inches but range from 20 to 48 inches. Thickness of the mollic epipedon ranges from 12 to 24 inches.

The A or Ap horizon is black (10YR 2/1) or very dark gray (10YR 3/1). It typically is loam but includes clay loam. The Bw horizon typically is dark grayish brown (10YR 4/2 or 2.5Y 4/2) loam or clay loam. The solum is neutral or slightly acid in the upper part. The C horizon has hue of 2.5Y, value of 5, and chroma of 2 to 4. It is calcareous loam or clay loam.

Okoboji Series

The Okoboji series consists of very poorly drained soils in upland depressions. Permeability is moderately slow. These soils formed in local alluvium washed from the adjacent uplands. Slopes range from 0 to 1 percent.

Okoboji soils are commonly adjacent to Canisteo, Harps, and Wacousta soils. Those soils have a thinner mollic epipedon than Okoboji soils. Canisteo and Harps soils occur as rims above the Okoboji soils on the landscape, are calcareous, and have free carbonates in the A horizon.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes; 75 feet east and 720 feet south of the northwest corner of sec. 4, T. 84 N., R. 24 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; mildly alkaline; abrupt smooth boundary.

A1—8 to 14 inches; black (N 2/0) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

A2—14 to 23 inches; black (N 2/0) silty clay loam, dark gray (10YR 4/1) dry; weak fine prismatic structure parting to weak fine subangular; friable; neutral; gradual smooth boundary.

A3—23 to 32 inches; black (10YR 2/1) silty clay loam, gray (10YR 5/1) dry; weak fine prismatic structure; friable; neutral; gradual smooth boundary.

Bg—32 to 40 inches; dark gray (5Y 4/1) silty clay loam that has streaks of very dark gray (10YR 3/1); common fine distinct yellowish brown (10YR 5/4) mottles, few fine prominent strong brown (7.5YR 5/6) mottles, and few fine faint olive gray (5Y 5/2) mottles; weak fine subangular structure; friable; lime segregations in the lower part; mildly alkaline; gradual smooth boundary.

BCg—40 to 47 inches; gray (5Y 5/1) silty clay loam; common fine prominent strong brown (7.5YR 5/6) mottles; weak medium subangular blocky structure; friable; light gray (5Y 7/1) lime accumulations; dark gray 5Y 4/1) channel fills; slightly effervescent; moderately alkaline; gradual smooth boundary.

Cg—47 to 60 inches; gray (5Y 5/1) and some dark gray (5Y 4/1) silty clay loam; few fine faint olive gray (5Y 5/2) mottles and common fine prominent strong brown (7.5YR 5/6) mottles; massive; friable; slightly effervescent; moderately alkaline.

Thickness of the solum ranges from 40 to 60 inches. Depth to carbonates ranges from 20 to 50 inches. Thickness of the mollic epipedon ranges from 24 to 36 inches.

The A horizon is black (N 2/0 or 10YR 2/1) silty clay loam or mucky silt loam. The Bg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2 with mottles of higher chroma. It typically is silty clay loam. The solum is neutral to moderately alkaline. The Cg horizon typically is calcareous silty clay loam, but some pedons have thin strata of loam. The Cg horizon is mildly alkaline or moderately alkaline.

Ottosen Series

The Ottosen series consists of somewhat poorly drained soils on uplands. These soils formed in glacial or lacustrine sediment that overlies calcareous glacial till. Permeability is moderately slow in the upper part of the profile and moderate in the lower part. Native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Ottosen soils are similar to Nicollet soils and are commonly adjacent to Bode and Kossuth soils. Bode soils are well drained. Nicollet soils contain less clay in the solum. Kossuth soils have a grayer B horizon, are poorly drained, and are on lower landscape positions.

Typical pedon of Ottosen clay loam, 1 to 3 percent slopes; 2,200 feet west and 2,520 feet north of the southeast corner of sec. 11, T. 85 N., R. 24 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; common fine roots; medium acid; abrupt smooth boundary.

A1—8 to 13 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; common fine roots; medium acid; clear smooth boundary.

A2—13 to 18 inches; very dark grayish brown (10YR 3/2) clay loam, grayish brown (10YR 5/2) dry; many black (10YR 2/1) and common dark grayish brown (10YR 4/2) coatings on faces of peds; moderate fine subangular blocky structure; friable; common fine roots; slightly acid; gradual smooth boundary.

BA—18 to 25 inches; dark grayish brown (2.5Y 4/2) clay loam; very dark gray (10YR 3/1) coatings on faces of peds; moderate fine subangular blocky structure; firm; neutral; gradual smooth boundary.

Bw—25 to 31 inches; dark grayish brown (2.5Y 4/2) clay loam; very dark gray (10YR 3/1) coatings on faces of peds; moderate fine and medium subangular blocky structure; firm; common clay films; neutral; gradual smooth boundary.

BC—31 to 35 inches; dark grayish brown (2.5Y 4/2) clay loam; few fine faint olive brown (2.5Y 4/4) mottles; weak fine prismatic structure parting to moderate fine subangular; firm; few fine faint iron and manganese concretions; neutral; clear wavy boundary.

2C—35 to 60 inches; dark grayish brown (2.5Y 4/2) and olive gray (5Y 4/2) loam; common fine distinct yellowish brown (10YR 5/6) mottles; massive; friable; slightly effervescent; mildly alkaline; common fine calcium carbonate concretions.

Thickness of the solum and depth to carbonates typically are 30 to 40 inches and range from 24 to 50 inches. Thickness of the mollic epipedon ranges from 12 to 24 inches.

The Ap and A1 horizons are black (N 2/0 or 10YR 2/1). The A horizon is silty clay loam or clay loam. It is medium acid to neutral. The Bw horizon has mottles that range in hue from 10YR to 2.5Y, in value from 4 to 6, and in chroma from 3 to 8. The Bw horizon is silty clay loam or clay loam. It is slightly acid or neutral. The 2C horizon typically has hue of 5Y, but in some pedons it has hue of 2.5Y, value of 4 or 5, and chroma of 2 to 4.

Palms Series

The Palms series consists of very poorly drained soils in depressions on uplands. Permeability is moderately rapid in the upper part and moderate in the lower part. These soils formed in 16 to 50 inches of organic material overlying stratified loamy mineral sediment. Native vegetation was marsh grasses and sedges. Slopes range from 0 to 1 percent.

Palms soils are commonly adjacent to Canisteo, Harps, and Okoboji soils. Canisteo, Harps, and Okoboji soils are mineral soils. The Canisteo and Harps soils are calcareous.

Typical pedon of Palms muck, 0 to 1 percent slopes; 1,950 feet west and 60 feet south of the northeast corner of sec. 14, T. 83 N., R. 21 W.

Oap—0 to 7 inches; black (N 2/0) sapric material, very dark gray (10YR 3/1) dry; moderate fine granular structure; slightly sticky; neutral; abrupt smooth boundary.

Oa1—7 to 15 inches; black (N 2/0) sapric material; very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to moderate fine granular; slightly sticky; neutral; clear smooth boundary.

Oa2—15 to 26 inches; black (10YR 2/1) sapric material, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure; slightly sticky; few shell fragments; neutral; clear smooth boundary.

2C1—26 to 41 inches; light olive brown (2.5Y 5/3) silt loam; weak medium subangular blocky structure; friable; strong brown (7.5YR 4/6) iron accumulations in root channels; black (10YR 2/1) krotovina at 32 to 35 inches; few shell fragments; mildly alkaline; clear wavy boundary.

2C2—41 to 48 inches; dark grayish brown (2.5Y 4/2) and very dark grayish brown (2.5Y 3/2) silt loam; weak medium subangular blocky and weak thin platy structure; friable; strong brown (7.5YR 4/6) iron oxides in root channels; neutral; clear wavy boundary.

2C3—48 to 60 inches; light olive gray (5Y 6/2) silt loam; few fine prominent strong brown (7.5YR 5/8) mottles and common fine prominent strong brown (7.5YR 5/6) mottles; weak medium platy structure; friable; strong brown (7.5YR 4/6) oxides in root channels; mildly alkaline.

The depth to mineral soil ranges from 16 to 50 inches.

The organic layers are black (N 2/0 or 10YR 2/1) or very dark brown (10YR 2/2). The organic part is primarily sapric material, but hemic layers 10 inches or less in thickness are present in some pedons. These organic layers are neutral to mildly alkaline. The 2C horizon has hue of 10YR, 2.5Y, or 5Y; value of 3 to 7; and chroma of 1 to 3. It ranges from silty clay loam to fine sandy loam and is neutral to moderately alkaline.

Rolfe Series

The Rolfe series consists of very poorly drained, slowly permeable soils in depressions on uplands. These soils formed in glacial till sediment in shallow depressions. Native vegetation was wet prairie and marsh grasses. Slopes range from 0 to 1 percent. The Rolfe soils in Story County are taxadjuncts because they have a slightly thinner surface layer than is definitive for the Rolfe series.

Rolfe soils are commonly adjacent to Clarion and Nicollet soils. Clarion soils are well drained. Nicollet soils are somewhat poorly drained. Both soils are upslope from Rolfe soils.

Typical pedon from an area of Rolfe silt loam, 0 to 1 percent slopes; 486 feet east and 920 feet south of the center of sec. 26, T. 83 N., R. 22 W.

Ap—0 to 9 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak medium granular structure; friable; medium acid; abrupt smooth boundary.

E1—9 to 13 inches; dark grayish brown (10YR 4/2) silt loam; light brownish gray (10YR 6/2) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium platy structure; friable; medium acid; clear smooth boundary.

E2—13 to 19 inches; dark gray (10YR 4/1) silt loam, light gray (10YR 7/1) dry; moderate thin platy structure; friable; medium acid; abrupt smooth boundary.

BE—19 to 24 inches; dark gray (10YR 4/1) clay loam, gray (10YR 6/1) dry; weak thin platy structure parting to moderate fine subangular blocky; friable; medium acid; clear smooth boundary.

Btg1—24 to 32 inches; olive gray (5Y 5/2 and 5Y 4/2) clay, gray (5Y 5/1) and dark gray (5Y 4/1) dry; very dark gray (N 3/0) coatings on faces of peds; few fine prominent strong brown (7.5YR 5/8) mottles; moderate fine subangular blocky structure; firm; thin continuous clay films; medium acid; gradual smooth boundary.

Btg2—32 to 39 inches; olive gray (5Y 4/2) clay loam; very dark gray (5Y 3/1) coatings on faces of peds; common fine prominent strong brown (7.5YR 5/8) mottles; moderate medium subangular blocky structure; firm; thin patchy clay films; medium acid; gradual smooth boundary.

Btg3—39 to 45 inches; dark gray (5Y 4/1) sandy clay loam; very dark gray (5Y 3/1) coatings on faces of peds; common fine prominent strong brown (7.5YR 5/8) mottles; weak medium subangular blocky structure; friable; thin patchy clay films; slightly acid; abrupt smooth boundary.

Btg4—45 to 52 inches; olive (5Y 5/3) clay loam; common fine prominent strong brown (7.5YR 5/8) mottles; weak coarse subangular blocky structure; friable; some very dark gray (10YR 3/1) manganese concretions; neutral; abrupt smooth boundary.

C—52 to 60 inches; olive (5Y 5/3) clay loam; common fine prominent strong brown (7.5YR 5/8) mottles; massive; friable; some very dark gray (10YR 3/1) manganese concretions; moderately alkaline; slightly effervescent.

Thickness of the solum is about 40 to 55 inches, and depth to carbonates ranges from 42 to 60 inches. The surface layer typically has mollic colors to a plow layer depth of about 9 inches.

The Ap horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). It typically is silt loam but in places is loam or silty clay loam. The E horizon typically is dark gray (10YR 4/1), dark grayish brown (10YR 4/2), or gray (10YR 5/1 or 6/1). It is silt loam or loam. The A horizon ranges from strongly acid to slightly acid, and the B horizon ranges from medium acid to neutral. The Bt horizon has hue of 5Y, value of 4 to 6, and chroma of 1 or 2. The upper part of the B horizon is clay, silty clay, or clay loam. The C horizon ranges from sandy loam to clay loam. It is neutral to moderately alkaline.

Sparta Series

The Sparta series consists of excessively drained, rapidly permeable soils on uplands and stream terraces. These soils formed in eolian sand or sandy alluvium that was reworked by wind. Native vegetation was prairie grasses. Slopes range from 2 to 14 percent.

Sparta soils are commonly adjacent to Dickinson and Farrar soils. Dickinson soils have more clay and less sand in the solum and are well drained and somewhat excessively drained. The well drained Farrar soils have more clay and less sand in the solum and are loamy in the lower part of the B horizon and in the C horizon. Farrar soils are downslope from Sparta soils.

Typical pedon of Sparta loamy fine sand, 5 to 9 percent slopes; 450 feet south and 1,200 feet east of the northwest corner of sec. 29, T. 83 N., R. 23 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) dry; weak very fine granular structure; very friable; neutral; abrupt smooth boundary.

A—9 to 16 inches; dark brown (10YR 3/3) loamy fine sand, grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; very friable; medium acid; gradual smooth boundary.

Bw—16 to 32 inches; dark yellowish brown (10YR 4/4) loamy fine sand; weak coarse subangular blocky structure; very friable; medium acid; gradual wavy boundary.

BC—32 to 39 inches; brown (7.5YR 4/4) loamy fine sand; weak coarse subangular blocky structure; very friable; slightly acid; gradual wavy boundary.

C—39 to 60 inches; brown (10YR 5/4) sand; single grain; loose; loamy sand iron band at 50 to 52 inches; slightly acid.

Thickness of the solum ranges from 24 to 40 inches. Thickness of the mollic epipedon ranges from 10 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 to 3. It typically is loamy fine sand but includes fine sand and loamy sand. The A horizon ranges from neutral to medium acid. The Bw horizon has hue of 10YR or 7.5YR, value of 4 to 6, and chroma of 3 to 6. It typically is loamy fine sand but includes loamy sand, sand, and fine sand. The B horizon is slightly acid to strongly acid. The C horizon has hue of 10YR, value of 4 to 6, and chroma of 3 to 6.

Spillville Series

The Spillville series consists of moderately well drained or somewhat poorly drained, moderately permeable soils on bottom lands. These soils formed in loamy alluvium under a native vegetation of prairie grasses. Slopes range from 0 to 2 percent.

Spillville soils are similar to Coland and Terril soils and are commonly adjacent to Coland and Hanlon soils. Coland soils contain more clay and less sand. Terril soils have a thinner A horizon. Hanlon soils contain less clay and more sand.

Typical pedon of Spillville loam, 0 to 2 percent slopes; 90 feet south and 930 feet east of the northwest corner of sec. 1, T. 83 N., R. 24 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; abrupt smooth boundary.

A1—8 to 22 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; moderate fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A2—22 to 35 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; moderate fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A3—35 to 50 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; very dark brown (10YR 2/2) coatings on faces of peds; weak medium subangular blocky structure; friable; neutral; gradual smooth boundary.

A4—50 to 60 inches; very dark gray (10YR 3/1) loam, dark grayish brown (10YR 4/2) dry; few fine distinct strong brown (7.5YR 5/6) mottles; weak coarse prismatic structure parting to weak medium subangular blocky; friable; neutral; clear smooth boundary.

Thickness of the solum ranges from 36 to 60 or more inches. Thickness of the mollic epipedon ranges from 36 to 60 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. Below a depth of 36 inches, it ranges from loam to sandy loam. The A horizon is neutral or slightly acid.

Storden Series

The Storden series consists of well drained, moderately permeable soils on knobs and hills of glacial moraine uplands. These soils formed in calcareous glacial till. Native vegetation was prairie grasses. Slopes range from 5 to 50 percent.

Storden soils are commonly adjacent to Hayden and Lester soils. Hayden and Lester soils are more acid and are leached to a greater depth.

Typical pedon of Storden loam, 14 to 18 percent slopes, severely eroded; about 70 feet west and 80 feet south of the northeast corner of sec. 18, T. 82 N., R. 23 W.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) loam mixed with streaks and pockets of light olive brown (2.5Y 5/4) loam; weak fine granular structure; friable; few pebbles; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C—8 to 60 inches; light olive brown (2.5Y 5/4) loam; few medium distinct grayish brown (2.5Y 5/2) and few fine prominent strong brown (7.5YR 5/6) mottles; massive; friable; few pebbles; strongly effervescent; moderately alkaline.

Thickness of the solum is commonly the same as thickness of the A horizon. Free carbonates are in all horizons.

Uneroded A horizons have hue of 10YR and value and chroma of 2 or 3. Eroded A horizons have hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 2 to 4. The A horizon is mildly alkaline or moderately alkaline and slightly effervescent or strongly effervescent.

The Storden soils in map units 62D, 62E, and 62F are taxadjuncts to the series because they have a slightly darker surface horizon than is defined for the series.

Talcot Series

The Talcot series consists of poorly drained soils on upland drainageways and stream terraces. These soils formed in loamy glacial outwash over sandy sediment. Permeability is moderate in the solum and rapid in the substratum. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Talcot soils are similar to and commonly adjacent to Biscay soils. Talcot soils typically are moderately alkaline in the A horizon whereas Biscay soils are neutral in the A horizon.

Typical pedon of Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes; 20 feet west and 1,240 feet north of the center of sec. 21, T. 84 N., R. 23 W.

Ap—0 to 8 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

A1—8 to 12 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

A2—12 to 19 inches; very dark gray (5Y 3/1) clay loam, dark gray (10YR 4/1) dry; few fine distinct dark gray (5Y 4/1) mottles; weak medium subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

Bg1—19 to 25 inches; dark gray (5Y 4/1) clay loam; few very dark gray (5Y 3/1) coatings on faces of peds; weak medium subangular blocky structure; friable;

slightly effervescent; moderately alkaline; gradual smooth boundary.

Bg2—25 to 30 inches; dark gray (5Y 4/1) clay loam; common fine distinct olive gray (5Y 4/2) mottles; weak medium subangular blocky structure; friable; slightly effervescent; moderately alkaline; gradual smooth boundary.

Bg3—30 to 35 inches; mixed dark gray (5Y 4/1) and olive gray (5Y 4/2) sandy loam; weak coarse subangular blocky structure; friable; slightly effervescent; moderately alkaline; clear smooth boundary.

2C1—35 to 41 inches; olive gray (5Y 5/2) medium sand; common medium prominent strong brown (7.5YR 5/6) mottles and common fine prominent dark reddish brown (5YR 2/2) mottles; single grain; loose; slightly effervescent; moderately alkaline; clear smooth boundary.

2C2—41 to 45 inches; light olive gray (5Y 6/2) loamy fine sand and loamy very fine sand; single grain; loose; slightly effervescent; moderately alkaline; clear smooth boundary.

2C3—45 to 60 inches; light olive gray (5Y 6/2) and olive gray (5Y 5/2) fine sand; few fine distinct yellowish brown (10YR 5/6) mottles; single grain; loose; slightly effervescent; moderately alkaline.

Thickness of the solum and depth to the 2C horizon range from 24 to 40 inches. Thickness of the mollic epipedon ranges from 14 to 24 inches.

The A horizon has hue of 10YR through 5Y, value of 2 or 3, and chroma of 1; or it is N 2/0 or N 3/0. It is clay loam or silty clay loam. The Bg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. The texture of the Bg2 horizon ranges from silty clay loam that is high in sand to sandy clay loam. The 2C horizon has hue of 2.5Y or 5Y, value of 4 through 6, and chroma of 2 through 4. It ranges from loamy fine sand to coarse sand.

Terril Series

The Terril series consists of moderately well drained, moderately permeable soils in waterways and narrow valleys in uplands and on foot slopes adjacent to steep areas. These soils formed in loamy alluvial sediment. Slopes range from 1 to 9 percent.

Terril soils are similar to Spillville soils and commonly are adjacent to Clarion, Coland, and Storden soils. Clarion soils have a mollic epipedon that is less than 24 inches thick and are above the Terril soils on the landscape. Coland soils have poorer internal drainage than Terril soils and are below the Terril soils on the landscape. Spillville soils have a thicker A horizon. Storden soils are light colored and calcareous and are above the Terril soils on the landscape.

Typical pedon of Terril loam, 2 to 5 percent slopes; 2,630 feet east and 130 feet north of the southwest corner of sec. 23, T. 84 N., R. 22 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; weak medium subangular blocky structure parting to moderate fine granular; friable; few small pebbles; neutral; abrupt smooth boundary.

A1—8 to 23 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure parting to moderate fine granular; friable; neutral; gradual smooth boundary.

A2—23 to 32 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; very dark brown (10YR 2/2) coatings on faces of peds; moderate medium subangular blocky structure; friable; neutral; gradual smooth boundary.

Bw—32 to 41 inches; dark brown (10YR 3/3) loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; few fine distinct strong brown (7.5YR 5/8) oxides; moderate fine subangular blocky structure; friable; neutral; gradual smooth boundary.

BC—41 to 60 inches; brown (10YR 4/3) clay loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; few fine faint dark brown (7.5YR 3/4) mottles; weak medium subangular blocky structure; friable; neutral.

Thickness of the solum ranges from about 36 to 60 inches. Thickness of the mollic epipedon ranges from 24 to 42 inches.

The A horizon typically is black (10YR 2/1) or very dark brown (10YR 2/2). It is loam but includes clay loam and silt loam that are high in sand content. Some areas having recent overwash have surface horizons that are very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3). The BA horizon, where present, typically is dark brown (10YR 3/3) or brown (10YR 4/3) with darker coatings on the peds. The Bw horizon ranges from dark brown (10YR 3/3) to yellowish brown (10YR 5/6). The B horizon is commonly loam, sandy clay loam, or clay loam. The C horizon is loam or clay loam. The 2C horizon is sand or loamy sand below a depth of 5 to 6 feet in places. The solum is slightly acid or neutral.

Wacousta Series

The Wacousta series consists of very poorly drained, moderately permeable soils in upland depressions. These soils formed in local alluvium from adjacent uplands. Slopes range from 0 to 1 percent.

Wacousta soils are commonly adjacent to Canisteo and Harps soils. Canisteo and Harps soils have a calcareous A horizon. They occur as rims around and above the Wacousta soils.

Typical pedon of Wacousta silty clay loam, 0 to 1 percent slopes; 1,400 feet east and 110 feet north of the southwest corner of sec. 35, T. 82 N., R. 24 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A—8 to 13 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine subangular blocky structure; firm; neutral; clear smooth boundary.

Bw—13 to 18 inches; olive gray (5Y 5/2) silty clay loam; black (10YR 2/1) organic coatings on faces of peds; many medium distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable; slightly effervescent; mildly alkaline; clear smooth boundary.

Cg1—18 to 41 inches; olive gray (5Y 5/2) heavy silt loam; many medium distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; friable; organic coatings in root channels; mildly alkaline; strongly effervescent; gradual smooth boundary.

Cg2—41 to 60 inches; light gray (5Y 6/1) silt loam; many medium distinct strong brown (7.5YR 5/6) mottles; weakly stratified; friable; violently effervescent; moderately alkaline.

Thickness of the solum ranges from 10 to 24 inches. Depth to carbonates ranges from 12 to 20 inches. Thickness of the mollic epipedon ranges from 8 to 18 inches.

The A horizon is black (N 2/0 and 10YR 2/1) silty clay loam. In some pedons the A horizon is mucky silt loam. The Bw horizon, where present, has hue of 5Y, value of 4 through 6, and chroma of 1 or 2. Mottles of high chroma and hue of 2.5Y or 10YR are common. The Bw horizon typically is silty clay loam. The solum is neutral or mildly alkaline. The upper part of the Cg horizon is gray (5Y 5/1 or 6/1) to light olive gray (5Y 6/2) silt loam or silty clay loam. Very fine sandy loam, coarse silt loam, or silty clay loam strata are throughout the Cg horizon in places.

Wadena Series

The Wadena series consists of well drained soils. These soils formed in loamy alluvium that is underlain by sand and gravel on stream terraces and outwash areas on uplands. Permeability is moderate in the solum and rapid in the substratum. Native vegetation was prairie grasses. Slopes range from 0 to 5 percent.

Wadena soils are commonly adjacent to Estherville soils. Wadena soils differ from Estherville soils in having a loam rather than a sandy loam B horizon and in generally being deeper to calcareous sand and gravel.

Typical pedon of Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes; 1,480 feet north and 1,780 feet west of the center of sec. 16, T. 85 N., R. 23 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; weak medium subangular blocky structure; friable; medium acid; abrupt smooth boundary.

A—7 to 12 inches; dark brown (10YR 3/3) loam, brown (10YR 4/3) dry, dark brown (10YR 3/3) kneaded; very dark brown (10YR 2/2) coatings on faces of peds; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

BA—12 to 20 inches; dark yellowish brown (10YR 4/4) loam; dark brown (10YR 3/3) coatings on faces of peds; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

Bw—20 to 25 inches; brown (7.5YR 4/4) sandy loam; weak fine subangular blocky structure parting to weak fine granular; very friable; slightly acid; clear smooth boundary.

2C1—25 to 37 inches; strong brown (7.5YR 4/6) loamy sand; single grain; loose; slightly acid; clear smooth boundary.

2C2—37 to 44 inches; dark yellowish brown (10YR 4/6) loamy sand; single grain; loose; slightly acid; abrupt wavy boundary.

2C3—44 to 60 inches; yellowish brown (10YR 5/4) sand; single grain; loose; slightly effervescent; mildly alkaline.

Thickness of the solum and depth to the 2C horizon range from 24 to 40 inches. Thickness of the mollic epipedon ranges from 12 to 20 inches.

The A horizon ranges from 10 to 16 inches in thickness in most places. The A horizon has value and chroma of 2 or 3. In places, there is a very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) AB horizon. The B horizon is brown (10YR 4/3 or 7.5YR 4/4) to yellowish brown (10YR 5/6). It is loam that in many places grades to sandy clay loam or sandy loam in the lower part. In places, the BC horizon contains gravel and the BA horizon is dark brown (10YR 3/3) or very dark grayish brown (10YR 3/2). The 2C horizon is loamy sand, sand, and gravel. It ranges from brown (10YR 5/3) to yellowish brown (10YR 5/4) or strong brown (7.5YR 4/6) in places. The solum is neutral or slightly acid. The 2C horizon is slightly acid in the upper part and mildly alkaline or moderately alkaline in the lower part and is calcareous.

Waukee Variant

The Waukee Variant consists of well drained, moderately permeable soils on stream terraces. These soils formed in loamy alluvium. Native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Waukee Variant soils are commonly adjacent to Wadena soils. Waukee Variant soils have more clay in the upper part of the B horizon and are deeper to coarse sand and gravel than Wadena soils.

Typical pedon of Waukee Variant loam, 0 to 2 percent slopes; 800 feet west and 280 feet south of the northeast corner of sec. 19, T. 83 N., R. 23 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; strongly acid; abrupt smooth boundary.

A—8 to 22 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; weak fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

BA—22 to 40 inches; brown (10YR 4/3) loam; dark brown (10YR 3/3) coatings on faces of peds; weak medium subangular blocky structure; friable; medium acid; gradual smooth boundary.

Bw—40 to 60 inches; brown (10YR 4/3) loam; weak medium subangular blocky structure; friable; medium acid; clear smooth boundary.

BC—60 to 72 inches; brown (10YR 4/3) loam; dark brown (10YR 3/3) coatings on faces of peds; few fine faint strong brown (7.5YR 4/6) mottles; weak coarse subangular blocky structure; friable; medium acid; gradual smooth boundary.

C—72 to 83 inches; brown (10YR 4/3) loam; few fine faint brown (10YR 5/3) mottles and common fine faint strong brown (7.5YR 4/6) mottles; weak coarse subangular blocky structure; friable; medium acid.

Thickness of the solum typically is 48 to 60 inches or more. Depth to carbonates typically is 72 inches or more.

The A1 or Ap horizon is black (10YR 2/1) or very dark brown (10YR 2/2). It is loam or silt loam that is high in sand content. The B horizon has hue of 10YR and less commonly hue of 7.5YR, value of 4 or 5, and chroma of 3 to 6. It is loam or sandy clay loam. The lower part of the A horizon and the B horizon are medium acid or strongly acid.

Webster Series

The Webster series consists of poorly drained, moderately permeable soils on uplands. These soils formed in local alluvium derived from till and glacial till under prairie vegetation. Slopes range from 0 to 2 percent.

Webster soils are similar to Canisteo, Cordova, and Kossuth soils and are commonly adjacent to Canisteo and Nicollet soils. Canisteo soils are mildly alkaline in the solum. Cordova and Kossuth soils have more clay in the B horizon. Webster soils are poorly drained whereas Nicollet soils are somewhat poorly drained and occur at slightly higher elevations.

Typical pedon of Webster clay loam, 0 to 2 percent slopes; 860 feet north and 40 feet east of the southwest corner of sec. 21, T. 84 N., R. 23 W.

Ap—0 to 8 inches; black (N 2/0) clay loam; very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A1—8 to 13 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; clear smooth boundary.

A2—13 to 17 inches; very dark gray (N 3/0) clay loam, dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

Bg1—17 to 23 inches; very dark gray (5Y 3/1) clay loam; few fine faint dark gray (5Y 4/1) mottles; weak medium subangular blocky structure; friable; few fine distinct strong brown (7.5YR 5/6) oxides; neutral; gradual smooth boundary.

Bg2—23 to 31 inches; olive gray (5Y 5/2) clay loam; dark gray (5Y 4/1) coatings on faces of peds; few fine distinct strong brown (7.5YR 5/6) mottles; moderate medium subangular blocky structure; friable; neutral; clear smooth boundary.

Bg3—31 to 38 inches; olive gray (5Y 5/2) clay loam; dark gray (5Y 4/1) and very dark gray (5Y 3/1) coatings on faces of peds; few fine distinct strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure; friable; common white (5Y 8/2) calcium carbonate accumulations; very dark gray (5Y 3/1) krotovina at a depth of 34 to 36 inches; neutral; clear smooth boundary.

Cg1—38 to 41 inches; olive gray (5Y 5/2) loam; many medium distinct strong brown (7.5YR 5/6) mottles; massive; friable; few dark reddish brown (5YR 2/2) manganese concretions; common white (5Y 8/2) calcium carbonate accumulations; slightly effervescent; mildly alkaline; clear smooth boundary.

Cg2—41 to 49 inches; olive gray (5Y 5/2) loam; few fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; lens of sandy loam at a depth of 47 to 49 inches; slightly effervescent; mildly alkaline; gradual smooth boundary.

Cg3—49 to 60 inches; olive gray (5Y 5/2) sandy loam; common fine distinct yellowish brown (10YR 5/6) mottles; massive; friable; slightly effervescent; mildly alkaline; clear smooth boundary.

Thickness of the solum ranges from 24 to 40 inches, but it is as much as 50 inches in some pedons. The depth to free carbonates has about the same range as the solum thickness. Thickness of the mollic epipedon ranges from 14 to 24 inches.

The Ap and A1 horizons are black (N 2/0 or 10YR 2/1). They are clay loam or silty clay loam that is high in sand content. The Bg2 and Bg3 horizons have hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 or 2 with mottles of high or low chroma throughout. The Bg2 and Bg3 horizons typically are clay loam or silty clay loam that is high in sand. The A horizon is neutral and the Bg2 and Bg3 horizons are neutral or mildly alkaline. The Cg horizon ranges from olive gray (5Y 5/2) and light olive gray (5Y 6/2) with few mottles to mottled yellowish brown (10YR 5/8) and grayish brown (2.5Y 5/2). The Cg horizon typically is loam or clay loam but ranges to sandy loam and silty clay loam that is high in sand content. In places, thin strata of silty or sandy material are present. The Cg horizon is mildly alkaline or moderately alkaline.

Zenor Series

The Zenor series consists of somewhat excessively drained soils on upland outwash areas. Permeability is moderately rapid. These soils formed in poorly sorted material that is dominantly loam or sandy loam over loamy sand. Native vegetation was tall prairie grasses. Slopes range from 2 to 9 percent.

Zenor soils are commonly adjacent to Clarion and Storden soils. Clarion and Storden soils are finer textured and formed in glacial till. They are on similar landscape positions.

Typical pedon of Zenor sandy loam, 2 to 5 percent slopes; 800 feet south and 300 feet east of the northwest corner of sec. 27, T. 83 N., R. 23 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) sandy loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A—8 to 11 inches; very dark grayish brown (10YR 3/2) sandy loam, brown (10YR 5/3) dry; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

BA—11 to 16 inches; dark brown (10YR 3/3) sandy loam; weak fine subangular blocky structure; very friable; neutral; gradual smooth boundary.

Bw—16 to 23 inches; brown (10YR 4/3) sandy loam; weak medium subangular blocky structure; very friable; neutral; gradual smooth boundary.

BC—23 to 29 inches; dark yellowish brown (10YR 4/4) loamy sand; weak medium subangular blocky structure; very friable; mildly alkaline; clear smooth boundary.

2C1—29 to 38 inches; dark yellowish brown (10YR 4/4) loamy sand; single grain; loose; few fine shale fragments; neutral; clear wavy boundary.

2C2—38 to 60 inches; yellowish brown (10YR 5/4) gravelly loamy sand; single grain; loose; few fine shale fragments; strongly effervescent; moderately alkaline.

Thickness of the solum and depth to free carbonates range from 20 to 40 inches. A few pebbles are throughout the profile. Thickness of the mollic epipedon ranges from 7 to 16 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is sandy loam or loam. The Bw horizon has hue of 10YR, value of 4 or 5, and chroma of 3 or 5. It is sandy loam or loam. The solum is neutral or slightly acid. The 2C horizon has hue of 7.5YR, 10YR, or 2.5Y; value of 4 to 7; and chroma of 3 to 6. It is loamy sand, gravelly loamy sand, gravelly sand, or sand. The 2C horizon is neutral to moderately alkaline.

The Zenor soil in map unit 828C is a taxadjunct to the series because it has a slightly thinner surface layer than is defined for the series.

Zook Series

The Zook series consists of poorly drained, slowly permeable soils on bottom lands. In many places, the soils are adjacent to foot slopes and terraces. These soils formed in silty and clayey alluvium. Slopes range from 0 to 2 percent.

Zook soils are commonly adjacent to Coland and Spillville soils. Coland soils have lower clay content in the subsoil. Spillville soils are moderately well drained or somewhat poorly drained and are lower in clay content. They are on similar landscape positions.

Typical pedon of Zook silty clay loam, 0 to 2 percent slopes; 440 feet east and 42 feet north of the southwest corner of sec. 18, T. 83 N., R. 23 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak very fine subangular blocky structure; firm; slightly acid; abrupt smooth boundary.

A1—8 to 16 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine granular structure parting to moderate very fine subangular blocky; friable; neutral; gradual smooth boundary.

A2—16 to 24 inches; black (N 2/0) silty clay, very dark gray (10YR 3/1) dry; moderate very fine subangular blocky structure; firm; neutral; clear smooth boundary.

A3—24 to 36 inches; very dark gray (N 3/0) silty clay, dark gray (10YR 4/1) dry; few fine distinct strong brown (7.5YR 5/6) oxides; moderate medium prismatic structure parting to moderate fine angular blocky; very firm; neutral; gradual smooth boundary.

A4—36 to 51 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; few fine distinct strong brown (7.5YR 5/6) oxides; moderate medium prismatic structure parting to weak fine angular blocky; very firm; neutral; gradual smooth boundary.

AC—51 to 57 inches; very dark gray (5Y 3/1) silty clay loam; few fine distinct yellowish brown (10YR 5/8) and pale olive (5Y 6/3) mottles and few fine faint dark reddish brown (5YR 2/2) oxides; weak coarse prismatic structure; very firm; neutral; gradual smooth boundary.

C—57 to 60 inches; olive gray (5Y 5/2) and olive (5Y 5/3) silty clay loam; common fine distinct dark reddish brown (5YR 3/2) and strong brown (7.5YR 5/8) oxides; massive; firm; few dark gray (10YR 4/1) coatings in old root channels; neutral.

Thickness of the solum and the mollic epipedon range from 36 to 60 inches. The solum commonly is medium acid or slightly acid, but soils that are neutral or mildly alkaline but not calcareous to a depth of 50 inches or more are within the range of the series.

The A horizon typically is black (10YR 2/1 or N 2/0). It is silty clay loam to silty clay. The B and C horizons are very dark gray (10YR 3/1) to olive (5Y 5/3) silty clay loam to silty clay.

Formation of the Soils

This section describes the factors of soil formation and relates these factors to the soils in Story County. The formation of soils in the county involved many steps and processes. All are important in the development of the soils (*4*).

Factors of Soil Formation

Soil forms through the processes of the environment acting on soil material that is deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by—

- the physical and mineralogical composition of the parent material,
- the climate under which the soil has accumulated and existed since accumulation,
- the plant and animal life on and in the soil,
- the relief, or lay of the land,
- the length of time the forces of soil formation have acted on the soil material (*7, 10*), and
- man's influence on the soil.

Climate and vegetation are the active factors of soil formation. They act on the parent material, which has accumulated through the weathering of rocks, and slowly change it into a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of parent material into a soil profile. It may be much or little, but some time is required for horizon differentation. Generally, a long period is required for the development of distinct horizons. Man's influence on the soil is an additional important factor.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

Parent Material

The accumulation of parent material is the first step in the formation of a soil. All of the soils in the county formed in material that was transported from the site of the parent rock and redeposited at a new location through the action of glacial ice, water, wind, and gravity. The principal parent materials in Story County are glacial drift, alluvium, and eolian or wind-deposited sand. Much less extensive parent materials are organic deposits and residuum.

Glacial drift is material transported by glacial ice and water resulting from the melting of glaciers. Glacial till was deposited by glacial ice only. It is unsorted sediment in which particles range in size from boulders to clay.

Glacial till is the most important parent material in the formation of the soils of Story County. At least twice during the glacial period, continental ice or glaciers moved over the entire county. The third and last glacier, the Cary Drift (*11*), covered all but the extreme southeastern corner of the county.

The record of these ice invasions is contained in the unconsolidated rock material that was deposited by the melting ice and meltwater streams.

The oldest ice sheet, known as the Nebraskan, occurred some 2 million years ago (*6*). It was followed by the Aftonian interglacial period. The Kansan Glaciation is thought to have started about 1.2 million years ago, and was followed by the Yarmouth-Sangamon interglacial period.

The Cary Glaciation (*6, 9*) occurred between about 13,000 and 14,000 years ago, the time of glaciation decreasing from the east to the northwest. The evidence for the geological youth of the Cary Glaciation is the lack of deep weathering, the unleached calcareous till at a shallow depth, and the poorly developed surface drainage and many closed depressions. Canisteo, Clarion, Harps, Lester, Nicollet, Okoboji, Rolfe, Storden, and Webster soils formed in the Cary glacial drift. The Bode, Ottosen, and Kossuth soils formed in lacustrine deposits within the Cary Drift area.

Loess is a silty material deposited by wind. It consists mostly of silt and clay. It does not contain coarse sand or gravel because those materials were too large to be moved more than a short distance by wind, but it does contain small amounts of fine and very fine sand. Loess crops out on the side hills of section 35 in Collins township, and it has been discovered in borings and excavations in other parts of the county. It occurs below the Cary till and above the Kansan or Nebraskan till.

Alluvium is material that was deposited by waters on the flood plains and terraces along the streams and on upland outwash plains. This material occurs as lenses and layers of sand, gravel, silt, and clay. The thickness of alluvial material is variable. In most places along the

Skunk River and Indian Creek and the tributaries of these rivers, the sandy loam, loam, clay loam, and clay material ranges from 2 to about 9 feet in thickness and is underlain by alluvial sand and gravel. Along other streams on the upland outwash plains, most of the alluvial deposits range from 2 to 10 feet in thickness and are underlain by calcareous glacial till.

Some of the alluvial material has been transported only a short distance and has accumulated at the foot of the slope on which it originated. This material is called local alluvium, and it retains many characteristics of the soils in the area from which it was eroded. The Terril and Ankeny soils are the only soils formed in this material.

Zook, Coland, Spillville, and Hanlon soils are on the flood plains.

Flagler, Cylinder, Biscay, Wadena, Talcot, and Estherville soils are on the stream terraces and outwash plains. These soils formed in moderately coarse to moderately fine textured loamy material 20 to 40 inches thick that is underlain by sand or gravel. Waukee Variant soils formed in 60 or more inches of medium textured alluvium that is underlain by sand or gravel on the terraces and outwash plains.

In the Zenor soils, sandy loam material ranging from less than 5 inches to 15 inches in thickness is underlain by gravelly sand or gravel.

Eolian material is sandy and loamy material deposited by wind. It consists of silts, fine and very fine sand, and a small amount of clay. Most of this material occurs as low mounds or dunes in the uplands and on the stream benches. The sand in these eolian deposits consists largely of quartz, which is highly resistant to weathering. It has not been altered appreciably since it was deposited. Farrar, Dickinson, and Sparta soils formed in this material.

Limestone and shale are the sedimentary formations in Story County. With the exception of a few outcrops, they are covered by glacial drift and alluvium. Most places in Story County have too much material above the limestone to economically mine it.

Organic deposits consist of plant material that has accumulated in old lakebeds, seepy hillside areas, and drainageways that support a thick growth of water-tolerant plants. Organic soils occupy wet areas in the county where poor drainage has retarded the decay of plant remains that have accumulated. In Story County, the thickness of the organic material ranges from 16 inches to more than 4 feet. Palms muck formed in these organic deposits.

Climate

According to available evidence, the soils of Story County formed under the influence of a midcontinental, subhumid climate over a period of at least 5,000 years. Between 5,000 and 16,000 years ago, the climate was conducive to the growth of forest vegetation (*8, 16*). The morphology of most of the soils in the county indicates that the climate under which the soils formed is similar to the present one. At present, the climate is fairly uniform throughout the county, but it is marked by wide seasonal extremes in temperature. Precipitation is distributed throughout the year.

Climate is a major factor in determining what soils develop from the various parent materials. The rate and intensity of hydrolysis, carbonation, oxidation, and other important chemical reactions in the soil are influenced by the climate. Temperature, rainfall, relative humidity, and the length of the frost-free period are important in determining the vegetation.

The influence of the general climate of the region is somewhat modified by the local conditions in or near the forming soil. For example, south-facing, dry, sandy slopes have a local climate or microclimate that is warmer and less humid than the average climate of nearby areas. Low lying, poorly drained areas are wetter and colder than most areas around them. These contrasts account for some of the differences in soils within the same general climatic regions.

Plant and Animal Life

All living organisms are important to soil formation. These include vegetation, animals, bacteria, and fungi. The vegetation chiefly determines the amount of organic matter, color of the surface layer, and the amount of nutrients in the soil. Such animals as earthworms and burrowing animals help to keep the soil open and porous. Bacteria and fungi decompose the vegetation, thus releasing nutrients for plant food.

Most of the soils in Story County formed under prairie grasses or a mixture of prairie grasses and water-tolerant plants. Because the grasses have many roots and tops that have decayed on or in the soil, the soils formed under these conditions, such as Clarion and Webster soils, have a thick, dark surface layer.

The soils that formed under timber vegetation have a thinner, lighter colored surface layer. The organic matter, derived principally from leaves, was deposited only on the surface of the soil.

A number of soils in the county formed first under prairie grasses and then under forest vegetation. These soils are intermediate. The Lester soil is an example.

Clarion and Hayden soils are members of a group of soils that formed from the same parent material and under a comparable environment except for native vegetation. Differences in native vegetation account for the main differences in morphology and soils of this group.

Relief

Relief is an important cause of differences among soils. Indirectly, it influences soil formation through its effect on drainage. In Story County, the relief ranges from level to very steep. Many nearly level areas are frequently flooded and have a high or periodically high water table. On stronger slopes, much of the rainfall runs off.

In general, the soils in Story County that formed where the water table was high or periodically high have a dominantly olive-gray subsoil, such as the Canisteo, Talcot, Biscay, and Webster soils. Those that formed where the water table was below the subsoil have a yellowish brown subsoil, such as the Clarion, Storden, and Lester soils. The Nicollet, Cylinder, and Ottosen soils formed where natural drainage was intermediate, and their subsoils are grayish brown and are mottled. Of the soils that formed under prairie, those that have a high water table generally have more organic matter in the surface layer than those that have good natural drainage.

Aspect, as well as gradient, has a significant influence on soil formation. South-facing slopes generally are warmer and drier than north-facing slopes and consequently support a different kind and amount of vegetation.

The influence of a porous, rapidly permeable parent material may override the influence of topography. Sparta soils, for example, are excessively drained, even though they are no more than moderately sloping, because they are rapidly permeable.

Clarion, Nicollet, and Webster soils are examples of soils that formed in the same kind of parent material and under similar vegetation but differ because of differences in topographic position. Webster soils are on nearly level upland swales. Nicollet soils are on very gently sloping knolls and side slopes.

Clarion soils are on gently sloping knolls and ridges to strongly sloping side slopes. Topography influences the drainage of these soils.

Terril soils are on foot slopes and have properties related to the soils upslope from which they receive sediment.

Time

Time is necessary for the various processes of soil formation to take place. The amount of time necessary ranges from a few days for the formation of soils in fresh alluvial deposits, such as Hanlon soils, to thousands of years for the leached horizons that make up the subsoil of Hayden soils. In general, if other factors are favorable, as time increases the texture of the subsoil becomes finer and a greater amount of soluble material is leached out as the soils continue to weather. Exceptions to this are soils formed in quartz sand, such as Sparta soils, or in other materials that are resistant to weathering. Such soils do not change much over a long period of time. Other exceptions are steep soils that have a small amount of water infiltration and receive a large amount of runoff. Such soils weather more slowly than soils in stable, less sloping landscapes.

Where organic material, such as trees, has been buried by later deposition through the action of ice, water, or wind, the age of a landscape can be determined by a process known as radiocarbon dating (*8*).

Hemlock wood was found in the lower strata of the Cary Drift in Cook Quarry near Ames. Ruhe used radiocarbon dating and determined the age of the wood and of the Cary Drift to be 13,000 to 14,000 years (*9*).

Time is needed for soil formation, but the age of the parent material does not necessarily reflect the true age of the soil formed in that material.

Man's Influence on the Soil

Important changes take place in the soil when it is drained and cultivated. Some of these changes have little effect on soil productivity; others have drastic effects. Changes caused by erosion generally are the most apparent. On many of the cultivated soils in the county, particularly the steeper slopes, part or all of the original surface layer has been lost through sheet erosion. Even in fields that are not eroded, the compaction of the soil by heavy machinery during cultivation reduces the thickness of the surface layer.

Man has done much to increase the productivity of the soils and to reclaim areas not suitable for crops. For example, tile drainage has been installed in many places in the county and has lowered the water table sufficiently to permit rowcropping of these areas. Through the use of commercial fertilizers, man has been able to counteract deficiencies in plant nutrients and make the soil more productive.

References

(1) American Association of State Highway [and Transportation] Officials. 1970. Standard specifications for highway materials and methods of sampling and testing. Ed. l0, 2 vol., illus.

(2) American Society for Testing and Materials. 1974. Method for classification of soils for engineering purposes. ASTM Stand. D 2487-69. *In* 1974 Annual Book of ASTM Standards, Part 19, 464 pp., illus.

(3) Iowa Crop and Livestock Reporting Service. 1980. 1980 Iowa agricultural statistics. Iowa Dep. Agric. Ann. Rep., 102 pp.

(4) Jenny, Hans. 1941. Factors of soil formation. McGraw-Hill Book Company, Inc., 281 pp., illus.

(5) League of Women Voters of Ames. 1979. This is Ames and Story County. League of Women Voters of Ames Handb., 51 pp.

(6) Prior, Jean Cutler. 1976. A regional guide to Iowa landforms. State of Iowa Ed. Ser. 3, 72 pp.

(7) Ruhe, Robert V. 1956. Ages and development of soil landscapes in relation to climatic and vegetational changes in Iowa. Soil Sci. Soc. Am. Proc. 20: 264-273, illus.

(8) Ruhe, Robert V., Rubin Meyer, and W.H. Scholtes. 1957. Late Pleistocene radiocarbon chronology in Iowa. Am. J. Sci. 255: 671-689.

(9) Ruhe, Robert V. 1969. Quaternary landscapes in Iowa. Iowa State Univ. Press, 255 pp., illus.

(10) Ruhe, Robert V. and R. B. Daniels. 1958. Soils, paleosols, and soil-horizon nomenclature. Soil Sci. Soc. Am. Proc. 22: 66-69, illus.

(11) Ruhe, R. V., W. P. Dietz, T. E. Fenton, and G. F. Hall. 1968. Iowan drift problem of northeastern Iowa. Iowa Geol. Surv. Rep. Invest. 7, pp. 1-40, illus.

(12) United States Department of Agriculture. 1904. Soil survey of Story County, Iowa. Bureau of Soils. 23 pp., illus.

(13) United States Department of Agriculture. 1941. Soil survey of Story County, Iowa. Bureau of Plant Indus. 59 pp., illus.

(14) United States Department of Agriculture. 1951. Soil survey manual. U.S. Dep. Agric. Handb. 18, 503 pp., illus. [Supplements replacing pp. 173-188 issued May 1962.]

(15) United States Department of Agriculture. 1975. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. Soil Conserv. Serv., U.S. Dep. Agric. Handb. 436, 754 pp., illus.

(16) Walker, Patrick H. 1966. Postglacial environments in relation to landscape and soils on the Cary Drift, Iowa. Iowa State Univ. Res. Bull. 549, pp. 838-875.

Glossary

Ablation till. Loose, permeable till deposited during the final downwasting of glacial ice. Lenses of crudely sorted sand and gravel are common.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Base saturation. The degree to which material having cation exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bench terrace. A raised, level or nearly level strip of earth constructed on or nearly on the contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Blowout. A shallow depression from which all or most of the soil material has been removed by wind. A blowout has a flat or irregular floor formed by a resistant layer or by an accumulation of pebbles or cobbles. In some blowouts the water table is exposed.

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Broad-base terrace. A ridge-type terrace built to control erosion by diverting runoff along the contour at a nonscouring velocity. The terrace is 10 to 20 inches high and 15 to 30 feet wide and has gently sloping sides, a rounded crown, and a dish-shaped channel along the upper side. It may be nearly level or have a grade toward one or both ends.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conservation tillage. A method of preparing a seedbed with a minimum of soil disturbance, leaving enough crop residue on the surface to protect the soil.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat). Fecal material deposited in water by aquatic organisms. The Lco horizon is a limnic layer that contains many fecal pellets.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Excess lime (in tables). Excess carbonates in the soil that restrict the growth of some plants.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, and clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Fragile (in tables). A soil that is easily damaged by use or disturbance.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by glacial melt water.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Glaciolacustrine deposits. Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial melt water. Many deposits are interbedded or laminated.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue at the surface of a mineral soil.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the Arabic numeral 2 precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Large stones (in tables). Rock fragments 3 inches (7.5 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Sandy loam and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Some types are terminal, lateral, medial, and ground.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Narrow-base terrace. A terrace no more than 4 to 8 feet wide at the base. A narrow-base terrace is similar to a broad-base terrace, except for the width of the ridge and channel.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Open space. A relatively undeveloped green or wooded area provided mainly within an urban area to minimize feelings of congested living.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial melt water.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor outlets (in tables). Refers to areas where surface or subsurface drainage outlets are difficult or expensive to install.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Sequum. A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides can occur at the bases of slip surfaces on slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where change in moisture is marked.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A1, A2, or A3) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. Includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Unstable fill (in tables). Risk of caving or sloughing on banks of fill material.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Valley fill. In glaciated regions, material deposited in stream valleys by glacial melt water. In nonglaciated regions, alluvium deposited by heavily loaded streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Recorded in the period 1964-78 at Colo, Iowa]

Month	Temperature						Precipitation				
				2 years in 10 will have--				2 years in 10 will have--			
	Average daily maximum	Average daily minimum	Average daily	Maximum temperature higher than--	Minimum temperature lower than--	Average number of growing degree days[1]	Average	Less than--	More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	24.0	5.4	14.7	49	-23	0	0.83	0.25	1.29	2	5.7
February---	31.1	11.6	21.4	58	-17	0	.93	.15	1.51	3	4.9
March------	43.2	23.8	33.5	78	-7	48	2.08	.84	3.12	4	4.7
April------	59.5	37.4	48.5	86	18	83	3.68	2.00	5.14	6	.5
May--------	71.1	48.1	59.6	90	29	321	4.52	2.57	6.24	8	.0
June-------	80.3	57.8	69.1	94	43	573	5.88	2.72	8.59	8	.0
July-------	84.1	62.2	73.2	97	46	719	3.71	1.78	5.37	7	.0
August-----	81.4	58.7	70.1	95	42	623	4.15	1.57	6.30	6	.0
September--	73.5	50.4	62.0	90	32	364	3.35	1.02	5.23	7	.0
October----	62.7	38.8	50.8	86	20	125	2.56	.68	4.06	5	.1
November---	45.4	26.6	36.0	70	0	0	1.35	.24	2.22	3	3.3
December---	30.7	14.1	22.4	58	-16	0	1.10	.48	1.62	3	5.8
Yearly:											
Average--	57.3	36.2	46.8	---	---	---	---	---	---	---	---
Extreme--	---	---	---	98	-23	---	---	---	---	---	---
Total----	---	---	---	---	---	2,856	34.14	28.87	39.59	62	25.0

[1] A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50 °F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1964-78 at Colo, Iowa]

Probability	Temperature: 24° F or lower	Temperature: 28° F or lower	Temperature: 32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	April 17	April 30	May 13
2 years in 10 later than--	April 13	April 25	May 9
5 years in 10 later than--	April 5	April 16	May 1
First freezing temperature in fall:			
1 year in 10 earlier than--	October 16	September 28	September 26
2 years in 10 earlier than--	October 21	October 4	September 29
5 years in 10 earlier than--	November 1	October 15	October 6

TABLE 3.--GROWING SEASON

[Recorded in the period 1964-78 at Colo, Iowa]

Probability	Length of growing season if daily minimum temperature is--: Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	186	155	140
8 years in 10	194	164	146
5 years in 10	209	181	157
2 years in 10	224	198	168
1 year in 10	231	207	174

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
6	Okoboji silty clay loam, 0 to 1 percent slopes	7,205	2.0
27B	Terril loam, 2 to 5 percent slopes	4,145	1.1
27C	Terril loam, 5 to 9 percent slopes	430	0.1
34C	Estherville sandy loam, 2 to 9 percent slopes	425	0.1
41B	Sparta loamy fine sand, 2 to 5 percent slopes	530	0.1
41C	Sparta loamy fine sand, 5 to 9 percent slopes	520	0.1
41D	Sparta loamy fine sand, 9 to 14 percent slopes	115	*
52B	Bode clay loam, 2 to 5 percent slopes	615	0.2
54	Zook silty clay loam, 0 to 2 percent slopes	2,020	0.6
55	Nicollet loam, 1 to 3 percent slopes	49,700	13.7
62C3	Storden loam, 5 to 9 percent slopes, severely eroded	405	0.1
62D	Storden loam, 9 to 14 percent slopes	565	0.2
62D3	Storden loam, 9 to 14 percent slopes, severely eroded	3,860	1.1
62E	Storden loam, 14 to 18 percent slopes	2,730	0.8
62E3	Storden loam, 14 to 18 percent slopes, severely eroded	940	0.3
62F	Storden loam, 18 to 25 percent slopes	1,365	0.4
65F	Lindley loam, 18 to 25 percent slopes	170	*
90	Okoboji mucky silt loam, 0 to 1 percent slopes	835	0.2
95	Harps loam, 1 to 3 percent slopes	19,810	5.4
107	Webster clay loam, 0 to 2 percent slopes	57,750	15.9
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	705	0.2
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	395	0.1
135	Coland clay loam, 0 to 2 percent slopes	10,925	3.0
136B	Ankeny fine sandy loam, 2 to 5 percent slopes	640	0.2
138B	Clarion loam, 2 to 5 percent slopes	72,505	19.9
138C	Clarion loam, 5 to 9 percent slopes	690	0.2
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	20,760	5.7
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	2,000	0.6
168B	Hayden loam, 2 to 5 percent slopes	1,005	0.3
168C	Hayden loam, 5 to 9 percent slopes	1,065	0.3
168E	Hayden loam, 9 to 18 percent slopes	245	0.1
168F	Hayden loam, 18 to 25 percent slopes	695	0.2
175	Dickinson fine sandy loam, 0 to 2 percent slopes	355	0.1
175B	Dickinson fine sandy loam, 2 to 5 percent slopes	550	0.2
175C	Dickinson fine sandy loam, 5 to 9 percent slopes	245	0.1
201B	Coland-Terril complex, 1 to 5 percent slopes	3,345	0.9
202	Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	170	*
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	515	0.1
221	Palms muck, 0 to 1 percent slopes	390	0.1
236B	Lester loam, 2 to 5 percent slopes	4,425	1.2
236C	Lester loam, 5 to 9 percent slopes	1,205	0.3
236C2	Lester loam, 5 to 9 percent slopes, moderately eroded	1,070	0.3
236D	Lester loam, 9 to 14 percent slopes	305	0.1
236D2	Lester loam, 9 to 14 percent slopes, moderately eroded	500	0.1
236E	Lester loam, 14 to 18 percent slopes	445	0.1
236F	Lester loam, 18 to 25 percent slopes	3,955	1.1
253B	Farrar fine sandy loam, 2 to 5 percent slopes	1,420	0.4
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	2,875	0.8
274	Rolfe silt loam, 0 to 1 percent slopes	245	0.1
284	Flagler sandy loam, 0 to 2 percent slopes	555	0.2
284B	Flagler sandy loam, 2 to 5 percent slopes	660	0.2
288	Ottosen clay loam, 1 to 3 percent slopes	2,245	0.6
356G	Hayden-Storden loams, 25 to 50 percent slopes	2,020	0.6
386	Cordova clay loam, 0 to 2 percent slopes	870	0.2
388	Kossuth silty clay loam, 0 to 2 percent slopes	6,180	1.7
485	Spillville loam, 0 to 2 percent slopes	6,360	1.7
506	Wacousta silty clay loam, 0 to 1 percent slopes	300	0.1
507	Canisteo clay loam, 0 to 2 percent slopes	25,860	7.1
536	Hanlon fine sandy loam, 0 to 2 percent slopes	355	0.1
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,930	0.5
638C2	Clarion-Storden loams, 5 to 9 percent slopes, moderately eroded	11,070	3.0
638D2	Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded	3,535	1.0
828B	Zenor sandy loam, 2 to 5 percent slopes	990	0.3
828C2	Zenor sandy loam, 5 to 9 percent slopes, moderately eroded	595	0.2
956	Harps-Okoboji complex, 0 to 2 percent slopes	3,910	1.1
1178	Waukee Variant loam, 0 to 2 percent slopes	380	0.1
1314	Hanlon-Spillville complex, channeled, 0 to 2 percent slopes	2,450	0.7
1585	Spillville-Coland complex, channeled, 0 to 2 percent slopes	1,955	0.5
4000	Urban land	310	0.1
5010	Pits, gravel	265	0.1

See footnote at end of table.

TABLE A.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS--Continued

Map symbol	Soil name	Acres	Percent
5030	Pits, quarry	170	*
5040	Orthents, loamy	1,770	0.5
5050	Orthents, sandy	80	*
5060	Pits, clay	20	*
	Water	905	0.2
	Total	363,520	100.0

* Less than 0.1 percent.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Soybeans	Oats	Smooth bromegrass	Grass-legume hay	Kentucky bluegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
6 Okoboji	84	32	67	4.3	3.4	3.3	7.3
27B Terril	118	45	94	7.0	5.0	4.2	8.3
27C Terril	113	43	91	6.7	4.8	4.2	8.0
34C Estherville	45	15	35	---	2.0	2.0	2.5
41B Sparta	61	23	45	---	2.5	2.3	4.3
41C Sparta	56	21	42	---	2.3	2.0	3.8
41D Sparta	---	---	35	---	2.2	1.6	3.6
52B Bode	103	39	77	6.1	4.3	3.8	7.1
54 Zook	96	36	72	4.0	4.0	4.0	---
55 Nicollet	116	44	93	---	5.0	4.1	8.3
62C3 Storden	86	33	68	---	3.6	3.3	6.0
62D Storden	83	32	66	---	3.5	3.3	5.8
62D3 Storden	77	29	62	---	3.2	2.6	5.3
62E Storden	68	26	54	---	3.0	2.5	4.8
62E3 Storden	---	---	35	---	2.5	2.2	4.2
62F Storden	---	---	---	---	2.2	1.6	3.7
65F Lindley	---	---	---	2.0	1.2	1.8	2.0
90 Okoboji	84	32	67	4.3	3.4	3.3	7.3
95 Harps	95	36	76	5.0	4.0	3.3	6.6
107 Webster	110	42	88	6.6	4.4	4.2	7.3
108 Wadena	72	27	60	---	2.7	2.7	4.8
108B Wadena	70	27	60	---	2.8	2.7	4.7

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Smooth bromegrass	Grass-legume hay	Kentucky bluegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
135 Coland	110	42	83	6.0	4.6	4.1	7.6
136B Ankeny	78	29	58	4.3	3.5	3.0	5.8
138B Clarion	110	42	88	6.7	4.6	4.2	7.6
138C Clarion	105	40	84	6.3	4.4	3.8	7.3
138C2 Clarion	102	39	82	6.2	4.3	3.8	7.1
138D2 Clarion	93	35	74	5.5	3.9	3.7	6.5
168B Hayden	98	37	78	---	4.1	3.5	6.8
168C Hayden	93	35	74	---	3.9	3.5	6.5
168E Hayden	69	26	55	---	2.9	2.3	4.8
168F Hayden	---	---	---	---	3.0	3.0	4.5
175 Dickinson	83	32	62	5.0	3.0	2.7	5.0
175B Dickinson	81	31	60	4.8	3.0	2.7	5.0
175C Dickinson	76	29	57	4.5	2.8	2.5	4.6
201B Coland-Terril	98	37	78	6.4	4.0	3.5	6.6
202 Cylinder	88	33	70	5.3	3.7	3.3	6.1
203 Cylinder	103	39	82	6.2	4.3	3.8	7.1
221 Palms	80	30	65	---	3.2	3.3	5.3
236B Lester	105	40	83	---	4.5	3.8	7.3
236C Lester	95	36	75	---	4.0	3.5	6.5
236C2 Lester	92	35	74	---	3.9	3.6	6.3
236D Lester	86	33	69	---	3.6	3.5	6.0
236D2 Lester	83	31	66	---	3.5	3.3	5.8
236E Lester	75	30	54	---	2.9	2.3	4.8

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Smooth bromegrass	Grass-legume hay	Kentucky bluegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
236F: Lester	---	---	---	---	3.0	3.0	4.5
253B: Farrar	86	33	69	5.2	3.6	3.3	6.0
259: Biscay	100	38	80	---	4.0	3.8	6.6
274: Rolfe	86	33	69	4.5	3.0	3.3	5.0
284: Flagler	72	27	58	4.3	3.0	2.3	5.0
284B: Flagler	70	26	56	4.1	2.9	2.1	4.8
288: Ottosen	111	43	88	6.6	4.7	4.0	7.8
356G: Hayden-Storden	---	---	---	---	---	---	1.3
386: Cordova	104	40	78	---	4.0	4.3	7.0
388: Kossuth	98	37	83	5.9	4.2	4.0	5.9
485: Spillville	122	46	98	7.3	5.1	4.2	8.6
506: Wacousta	100	38	80	7.0	4.0	2.0	6.6
507: Canisteo	105	40	84	---	4.2	3.8	7.0
536: Hanlon	90	34	72	5.3	3.8	3.3	6.3
559: Talcot	95	36	76	5.0	4.0	3.6	6.3
638C2: Clarion-Storden	95	36	78	---	3.9	3.4	6.8
638D2: Clarion-Storden	85	30	63	---	3.7	3.4	5.8
828B: Zenor	79	30	63	4.8	3.3	3.0	5.5
828C2: Zenor	72	27	58	4.3	3.0	2.7	5.0
956: Okoboji-Harps	88	33	70	4.6	3.6	3.3	7.0
1178: Waukee Variant	105	40	84	---	4.4	4.1	7.0
1314: Hanlon-Spillville	---	---	---	---	---	3.6	----
1585: Spillville-Coland	---	---	---	6.7	4.9	3.6	6.2

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Smooth bromegrass	Grass-legume hay	Kentucky bluegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
4000**. Urban land							
5010**, 5030**. Pits							
5040**, 5050**. Orthents							
5060**. Pits							

* Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

** See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 6.--CAPABILITY CLASSES AND SUBCLASSES

[Miscellaneous areas are excluded. Absence of an entry indicates no acreage]

Class	Total acreage	Major management concerns (Subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Acres	Acres	Acres
I	52,840	---	---	---
II	220,960	84,510	134,580	1,870
III	64,205	46,640	16,230	1,335
IV	9,270	8,220	---	1,050
V	4,405	---	4,405	---
VI	6,130	6,015	---	115
VII	2,190	2,190	---	---
VIII	---	---	---	---

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of-- <8	8-15	16-25	26-35	>35
6. Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
27B, 27C. Terril	---	Gray dogwood, Siberian peashrub, redosier dogwood, lilac.	Honeylocust, Russian-olive, Amur maple, blue spruce, northern white-cedar, eastern redcedar.	Eastern white pine, green ash.	---
34C. Estherville	Lilac, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, hackberry, Manchurian crabapple.	Honeylocust, jack pine, eastern white pine, green ash, bur oak, Russian-olive.	---	---
41B, 41C, 41D. Sparta	Siberian peashrub, Tatarian honeysuckle, lilac.	Eastern redcedar	Red pine, jack pine, Austrian pine.	Eastern white pine	---
52B. Bode	---	Redosier dogwood, lilac, gray dogwood, Siberian peashrub.	Eastern redcedar, Amur maple, hackberry, northern white-cedar, blue spruce, Russian-olive.	Eastern white pine, green ash.	---
54. Zook	---	Silky dogwood, Amur honeysuckle, American cranberrybush, Amur privet.	Norway spruce, northern white-cedar, Austrian pine, blue spruce, white fir, Washington hawthorn.	Eastern white pine	Pin oak.
55. Nicollet	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
62C3, 62D, 62D3, 62E, 62E3, 62F. Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
65F. Lindley	---	Silky dogwood, Amur honeysuckle, Amur privet, American cranberrybush.	Washington hawthorn, northern white-cedar, blue spruce, white fir.	Norway spruce, Austrian pine.	Eastern white pine, pin oak.
90. Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
95. Harps	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
107. Webster	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Hackberry, Amur maple, northern white-cedar, tall purple willow, white spruce.	Golden willow, green ash.	Eastern cottonwood, silver maple.
108, 108B. Wadena	Siberian peashrub, lilac, Tatarian honeysuckle.	Eastern redcedar, hackberry, Manchurian crabapple.	Jack pine, honeylocust, bur oak, Russian-olive, green ash, eastern white pine.	---	---
135. Coland	---	Redosier dogwood, Tatarian honeysuckle, American plum.	White spruce, hackberry, northern white-cedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.
136B. Ankeny	Lilac.	Eastern redcedar, Siberian peashrub, Russian-olive, Tatarian honeysuckle.	Hackberry, Norway spruce, red pine, eastern white pine, honeylocust, Amur maple, green ash.	---	---
138B, 138C, 138C2, 138D2. Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern white-cedar, blue spruce, Amur maple, Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
168B, 168C, 168E, 168F. Hayden	---	Redosier dogwood, gray dogwood, Siberian peashrub, lilac.	Hackberry, eastern redcedar, Russian-olive, Amur maple, northern white-cedar, blue spruce.	Eastern white pine, green ash.	---
175, 175B, 175C. Dickinson	Siberian peashrub, Tatarian honeysuckle, lilac.	Eastern redcedar, hackberry, Manchurian crabapple.	Eastern white pine, honeylocust, bur oak, Russian-olive, jack pine, green ash.	---	---
201B*:					
Coland	---	Redosier dogwood, Tatarian honeysuckle, American plum.	White spruce, hackberry, northern white-cedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
201B*: Terril	---	Gray dogwood, Siberian peashrub, redosier dogwood, lilac.	Honeylocust, Russian-olive, Amur maple, blue spruce, northern white-cedar, eastern redcedar.	Eastern white pine, green ash.	---
202, 203 Cylinder	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Blue spruce, northern white-cedar, Amur maple, white spruce.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
221 Palms	Common ninebark, whitebelle honeysuckle.	Amur honeysuckle, Amur privet, silky dogwood, nannyberry viburnum, Tatarian honeysuckle.	Tall purple willow	Golden willow, black willow.	Imperial Carolina poplar.
236B, 236C, 236C2, 236D, 236D2, 236E, 236F Lester	---	Redosier dogwood, Siberian peashrub, lilac, gray dogwood.	Hackberry, eastern redcedar, northern white-cedar, Amur maple, Russian-olive, blue spruce.	Eastern white pine, green ash.	---
253B Farrar	Lilac	Siberian peashrub, eastern redcedar, Tatarian honeysuckle, Russian-olive.	Green ash, red pine, honeylocust, Norway spruce, eastern white pine, Amur maple, hackberry.	---	---
259 Biscay	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Northern white-cedar, Amur maple, white spruce, hackberry, tall purple willow.	Green ash, golden willow.	Eastern cottonwood, silver maple.
274 Rolfe	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Amur maple, northern white-cedar, hackberry, white spruce, tall purple willow.	Golden willow, green ash.	Silver maple, eastern cottonwood.
284, 284B Flagler	Tatarian honeysuckle, Siberian peashrub, lilac.	Manchurian crabapple, hackberry, eastern redcedar.	Honeylocust, eastern white pine, jack pine, green ash, Russian-olive, bur oak.	---	---
288 Ottosen	---	Redosier dogwood, lilac, Tatarian honeysuckle.	Northern white-cedar, blue spruce, white spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
356G*: Hayden	---	Redosier dogwood, gray dogwood, Siberian peashrub, lilac.	Hackberry, eastern redcedar, Russian-olive, Amur maple, northern white-cedar, blue spruce.	Eastern white pine, green ash.	---
Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
386 Cordova	---	Tatarian honeysuckle, American plum, redosier dogwood.	Northern white-cedar, white spruce, hackberry, tall purple willow, Amur maple.	Green ash, golden willow.	Eastern cottonwood, silver maple.
388 Kossuth	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Tall purple willow, Amur maple, hackberry, white spruce, northern white-cedar.	Golden willow, green ash.	Eastern cottonwood, silver maple.
485 Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
506 Wacousta	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, eastern redcedar, bur oak, white spruce.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
507 Canisteo	---	Siberian peashrub, Tatarian honeysuckle, lilac, northern white-cedar.	Hackberry, bur oak, white spruce, eastern redcedar.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
536 Hanlon	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, blue spruce, white spruce, northern white-cedar.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
559 Talcot	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, white spruce, bur oak, eastern redcedar.	Green ash, golden willow, honeylocust.	Eastern cottonwood.
638C2*, 638D2*: Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern white-cedar, blue spruce, Amur maple, Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
638C2*, 638D2*:					
Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
828B, 828C2 Zenor	Siberian peashrub, Tatarian honeysuckle, lilac.	Hackberry, eastern redcedar, Manchurian crabapple.	Honeylocust, bur oak, jack pine, green ash, Russian-olive, eastern white pine.	---	---
956*:					
Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
Harps	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
1178 Waukee Variant	---	Siberian peashrub, lilac, Amur honeysuckle.	Russian-olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
1314*:					
Hanlon	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, blue spruce, white spruce, northern white-cedar.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
1585*:					
Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
Coland	---	Redosier dogwood, Tatarian honeysuckle, American plum.	White spruce, hackberry, northern white-cedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.
4000*. Urban land					
5010*, 5030*. Pits					
5040*, 5050*. Orthents					

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
5060*. Pits					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
6 Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, erodes easily.	Severe: ponding.
27B Terril	Slight	Slight	Moderate: slope.	Slight	Slight.
27C Terril	Slight	Slight	Severe: slope.	Slight	Slight.
34C Estherville	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
41B Sparta	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
41C Sparta	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
41D Sparta	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: droughty, slope.
52B Bode	Slight	Slight	Moderate: slope.	Slight	Slight.
54 Zook	Severe: wetness, flooding.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
55 Nicollet	Slight	Slight	Moderate: slope.	Slight	Slight.
62C3 Storden	Slight	Slight	Severe: slope.	Slight	Slight.
62D, 62D3 Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
62E, 62E3, 62F Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
65F Lindley	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
90 Okoboji	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus, erodes easily.	Severe: ponding.
95 Harps	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
107 Webster	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
108 Wadena	Slight	Slight	Moderate: small stones.	Slight	Slight.
108B Wadena	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
135 Coland	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
136B Ankeny	Slight	Slight	Moderate: slope.	Slight	Slight.
138B Clarion	Slight	Slight	Moderate: slope.	Slight	Slight.
138C, 138C2 Clarion	Slight	Slight	Severe: slope.	Slight	Slight.
138D2 Clarion	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
168B Hayden	Slight	Slight	Moderate: slope.	Slight	Slight.
168C Hayden	Slight	Slight	Severe: slope.	Slight	Slight.
168E Hayden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
168F Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
175 Dickinson	Slight	Slight	Slight	Slight	Slight.
175B Dickinson	Slight	Slight	Moderate: slope.	Slight	Slight.
175C Dickinson	Slight	Slight	Severe: slope.	Slight	Slight.
201B*:					
Coland	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
Terril	Slight	Slight	Moderate: slope.	Slight	Slight.
202, 203 Cylinder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
221 Palms	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
236B Lester	Slight	Slight	Moderate: slope.	Slight	Slight.
236C, 236C2 Lester	Slight	Slight	Severe: slope.	Slight	Slight.
236D, 236D2 Lester	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
236E, 236F Lester	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
253B Farrar	Slight	Slight	Moderate: slope.	Slight	Slight.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
259 Biscay	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
274 Rolfe	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding.
284 Flagler	Slight	Slight	Slight	Slight	Slight.
284B Flagler	Slight	Slight	Moderate: slope.	Slight	Slight.
288 Ottosen	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: slope, wetness, percs slowly.	Slight	Slight.
356G*:					
Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
386 Cordova	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
388 Kossuth	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
485 Spillville	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
506 Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
507 Canisteo	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
536 Hanlon	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
559 Talcot	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
638C2*:					
Clarion	Slight	Slight	Severe: slope.	Slight	Slight.
Storden	Slight	Slight	Severe: slope.	Slight	Slight.
638D2*:					
Clarion	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
828B Zenor	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
828C2 Zenor	Slight	Slight	Severe: slope.	Slight	Slight.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
956*:					
Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
Harps	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
1178 Waukee Variant	Slight	Slight	Slight	Slight	Slight.
1314*:					
Hanlon	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
Spillville	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
1585*:					
Spillville	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
Coland	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
4000*. Urban land					
5010*, 5030*. Pits					
5040*, 5050*. Orthents					
5060*. Pits					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--WILDLIFE HABITAT

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
6------------------- Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
27B----------------- Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
27C----------------- Terril	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
34C----------------- Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
41B----------------- Sparta	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
41C, 41D------------ Sparta	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
52B----------------- Bode	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
54------------------ Zook	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
55------------------ Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
62C3, 62D, 62D3, 62E, 62E3---------- Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
62F----------------- Storden	Poor	Fair	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
65F----------------- Lindley	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
90------------------ Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
95------------------ Harps	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
107----------------- Webster	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
108, 108B----------- Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
135----------------- Coland	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
136B---------------- Ankeny	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
138B---------------- Clarion	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
138C, 138C2, 138D2- Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
168B---------------- Hayden	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.

TABLE 9.--WILDLIFE HABITAT-Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
168C, 168E----------- Hayden	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
168F----------------- Hayden	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
175, 175B----------- Dickinson	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
175C----------------- Dickinson	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
201B*:										
Coland--------------	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
Terril--------------	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
202, 203------------- Cylinder	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
221------------------ Palms	Good	Poor	Poor	Poor	Poor	Good	Good	Fair	Poor	Good.
236B----------------- Lester	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236C, 236C2, 236D, 236D2, 236E-------- Lester	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236F----------------- Lester	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
253B----------------- Farrar	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
259------------------ Biscay	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.
274------------------ Rolfe	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
284, 284B----------- Flagler	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
288------------------ Ottosen	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
356G*:										
Hayden--------------	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Storden-------------	Poor	Fair	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
386------------------ Cordova	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
388------------------ Kossuth	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
485------------------ Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
506------------------ Wacousta	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.

See footnote at end of table.

TABLE 9.--WILDLIFE HABITAT-Continued

Soil name and map symbol	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
507------------------ Canisteo	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
536------------------ Hanlon	Good	Good	Good	Good	Good	Poor	Fair	Good	Good	Poor.
559------------------ Talcot	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
638C2*, 638D2*:										
Clarion-------------	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Storden-------------	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
828B---------------- Zenor	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
828C2--------------- Zenor	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
956*:										
Okoboji-------------	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
Harps---------------	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
1178---------------- Waukee Variant	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
1314*:										
Hanlon--------------	Good	Good	Good	Good	Good	Poor	Fair	Good	Good	Poor.
Spillville----------	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
1585*:										
Spillville----------	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
Coland--------------	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
4000*. Urban land										
5010*, 5030*. Pits										
5040*, 5050*. Orthents										
5060*. Pits										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
6 Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
27B Terril	Slight	Slight	Slight	Slight	Severe: low strength.	Slight.
27C Terril	Slight	Slight	Slight	Moderate: slope.	Severe: low strength.	Slight.
34C Estherville	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
41B Sparta	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
41C Sparta	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
41D Sparta	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: droughty, slope.
52B Bode	Slight	Moderate: shrink-swell.	Slight	Moderate: shrink-swell.	Severe: low strength.	Slight.
54 Zook	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Severe: flooding.
55 Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
62C3 Storden	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
62D, 62D3 Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
62E, 62E3, 62F Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
65F Lindley	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope, low strength.	Severe: slope.
90 Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
95 Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
107 Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
108, 108B Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
135: Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Severe: flooding.
136B: Ankeny	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.	Slight.
138B: Clarion	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
138C, 138C2: Clarion	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
138D2: Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
168B: Hayden	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
168C: Hayden	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
168E: Hayden	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
168F: Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
175, 175B: Dickinson	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.	Slight.
175C: Dickinson	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
201B*:						
Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Severe: flooding.
Terril	Slight	Slight	Slight	Slight	Severe: low strength.	Slight.
202, 203: Cylinder	Severe: cutbanks cave, wetness.	Moderate: shrink-swell, wetness.	Severe: wetness.	Moderate: shrink-swell, wetness.	Severe: frost action.	Slight.
221: Palms	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, frost action.	Severe: ponding, excess humus.
236B: Lester	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
236C, 236C2: Lester	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
236D, 236D2: Lester	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
236E, 236F: Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.

See footnote at end of table.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
253B--------------- Farrar	Slight---------	Slight---------	Slight---------	Slight---------	Severe: low strength.	Slight.
259---------------- Biscay	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness, frost action.	Moderate: wetness.
274---------------- Rolfe	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
284, 284B---------- Flagler	Severe: cutbanks cave.	Slight---------	Slight---------	Slight---------	Slight---------	Slight.
288---------------- Ottosen	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.	Slight.
356G*:						
Hayden-----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
Storden-----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
386---------------- Cordova	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action, low strength.	Moderate: wetness.
388---------------- Kossuth	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: shrink-swell, frost action, low strength.	Moderate: wetness.
485---------------- Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
506---------------- Wacousta	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
507---------------- Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
536---------------- Hanlon	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.
559---------------- Talcot	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
638C2*:						
Clarion-----------	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.
Storden-----------	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.
638D2*:						
Clarion-----------	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.

See footnote at end of table.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
638D2*:						
Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
828B Zenor	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
828C2 Zenor	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Slight.
956*:						
Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
1178 Waukee Variant	Slight	Slight	Slight	Slight	Slight	Slight.
1314*:						
Hanlon	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.
Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Severe: flooding.
1585*:						
Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Severe: flooding.
4000*. Urban land						
5010*, 5030*. Pits						
5040*, 5050*. Orthents						
5060*. Pits						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
6 Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
27B Terril	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
27C Terril	Slight	Severe: slope.	Slight	Slight	Good.
34C Estherville	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
41B Sparta	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
41C, 41D Sparta	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
52B Bode	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
54 Zook	Severe: percs slowly, wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, too clayey, flooding.	Severe: wetness, flooding.	Poor: too clayey, wetness, hard to pack.
55 Nicollet	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
62C3 Storden	Slight	Severe: slope.	Slight	Slight	Good.
62D, 62D3 Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
62E, 62E3, 62F Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
65F Lindley	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
90 Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
95 Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
107 Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
108, 108B Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
135----------------- Coland	Severe: flooding, wetness.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness.	Poor: wetness, hard to pack.
136B----------------- Ankeny	Severe: poor filter.	Severe: seepage.	Severe: seepage.	Severe: seepage.	Fair: thin layer.
138B----------------- Clarion	Slight-----------	Moderate: slope, seepage.	Slight-----------	Slight-----------	Good.
138C, 138C2--------- Clarion	Slight-----------	Severe: slope.	Slight-----------	Slight-----------	Good.
138D2--------------- Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
168B---------------- Hayden	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
168C---------------- Hayden	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
168E---------------- Hayden	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
168F---------------- Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
175, 175B----------- Dickinson	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
175C---------------- Dickinson	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
201B*:					
Coland--------------	Severe: flooding, wetness.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness.	Poor: wetness, hard to pack.
Terril--------------	Slight-----------	Moderate: seepage, slope.	Slight-----------	Slight-----------	Good.
202, 203------------ Cylinder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, seepage.
221----------------- Palms	Severe: subsides, ponding.	Severe: seepage, excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, seepage.	Poor: ponding, excess humus.
236B---------------- Lester	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
236C, 236C2--------- Lester	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.

See footnote at end of table.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
236D, 236D2: Lester	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
236E, 236F: Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
253B: Farrar	Slight	Moderate: slope, seepage.	Slight	Severe: seepage.	Good.
259: Biscay	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
274: Rolfe	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
284, 284B: Flagler	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: too sandy, seepage.
288: Ottosen	Severe: percs slowly, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
356G*:					
Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
386: Cordova	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
388: Kossuth	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
485: Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.
506: Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
507: Canisteo	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
536: Hanlon	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, seepage, wetness.	Fair: wetness.
559: Talcot	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
638C2*:					
Clarion	Slight	Severe: slope.	Slight	Slight	Good.

See footnote at end of table.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
638C2*:					
Storden	Slight	Severe: slope.	Slight	Slight	Good.
638D2*:					
Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
828B Zenor	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
828C2 Zenor	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
956*:					
Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
1178 Waukee Variant	Moderate: percs slowly.	Moderate: seepage.	Severe: seepage.	Slight	Good.
1314*:					
Hanlon	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, seepage, wetness.	Fair: wetness.
Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage. flooding.	Severe: wetness, flooding.	Fair: wetness.
1585*:					
Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.
Coland	Severe: flooding, wetness.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness.	Poor: wetness, hard to pack.
4000*. Urban land					
5010*, 5030*. Pits					
5040*, 5050*. Orthents					
5060*. Pits					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
6 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
27B, 27C Terril	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
34C Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.
41B, 41C Sparta	Good	Probable	Improbable: too sandy.	Fair: too sandy.
41D Sparta	Good	Probable	Improbable: too sandy.	Fair: slope, too sandy.
52B Bode	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
54 Zook	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
55 Nicollet	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
62C3 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
62D, 62D3 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
62E, 62E3, 62F Storden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
65F Lindley	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
90 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
95 Harps	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: large stones.
107 Webster	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
108, 108B Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
135 Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
136B Ankeny	Good	Probable	Improbable: too sandy.	Fair: large stones.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
138B, 138C, 138C2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
138D2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
168B, 168C Hayden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
168E Hayden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
168F Hayden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
175, 175B, 175C Dickinson	Good	Probable	Improbable: too sandy.	Good.
201B*:				
Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Terril	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
202, 203 Cylinder	Fair: wetness.	Probable	Improbable: too sandy.	Fair: area reclaim, small stones, thin layer.
221 Palms	Poor: wetness, low strength.	Improbable: excess humus, excess fines.	Improbable: excess humus, excess fines.	Poor: wetness, excess humus.
236B, 236C, 236C2 Lester	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
236D, 236D2 Lester	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
236E, 236F Lester	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
253B Farrar	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
259 Biscay	Poor: wetness.	Probable	Probable	Poor: area reclaim.
274 Rolfe	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
284, 284B Flagler	Good	Probable	Probable	Fair: small stones, area reclaim, thin layer.
288 Ottosen	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
356G*:				
Hayden	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
356G*:				
Storden	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
386 Cordova	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
388 Kossuth	Fair: wetness, shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
485 Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
506 Wacousta	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
507 Canisteo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
536 Hanlon	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
559 Talcot	Fair: wetness.	Probable	Probable	Fair: small stones, area reclaim, thin layer.
638C2*:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
638D2*:				
Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
828B, 828C2 Zenor	Good	Probable	Improbable: too sandy.	Fair: small stones, thin layer.
956*:				
Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
Harps	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: large stones.
1178 Waukee Variant	Good	Probable	Improbable: too sandy.	Fair: small stones.
1314*:				
Hanlon	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
1585*:				
Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
4000*. Urban land				
5010*, 5030*. Pits				
5040*, 5050*. Orthents.				
5060*. Pits				

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Limitations for-- Pond reservoir areas	Limitations for-- Embankments, dikes, and levees	Limitations for-- Aquifer-fed excavated ponds	Features affecting-- Drainage	Features affecting-- Terraces and diversions	Features affecting-- Grassed waterways
6----------------- Okoboji	Moderate: seepage.	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Erodes easily, ponding.	Wetness, erodes easily.
27B, 27C---------- Terril	Moderate: seepage, slope.	Moderate: piping.	Severe: no water.	Deep to water	Favorable------	Favorable.
34C--------------- Estherville	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
41B, 41C---------- Sparta	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
41D--------------- Sparta	Severe: seepage, slope.	Severe: seepage, piping.	Severe: no water.	Deep to water	Slope, too sandy, soil blowing.	Slope, droughty.
52B--------------- Bode	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Favorable------	Favorable.
54---------------- Zook	Slight---------	Severe: hard to pack, wetness.	Severe: slow refill.	Flooding, percs slowly, frost action.	Not needed-----	Not needed.
55---------------- Nicollet	Moderate: seepage.	Severe: piping.	Moderate: deep to water, slow refill.	Frost action---	Wetness--------	Favorable.
62C3-------------- Storden	Moderate: seepage, slope.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
62D, 62D3, 62E, 62E3, 62F-------- Storden	Severe: slope.	Moderate: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
65F--------------- Lindley	Severe: slope.	Moderate: piping.	Severe: no water.	Deep to water.	Slope, percs slowly, erodes easily.	Slope, erodes easily, percs slowly.
90---------------- Okoboji	Moderate: seepage.	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Erodes easily, ponding.	Wetness, erodes easily.
95---------------- Harps	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action---	Wetness--------	Wetness.
107--------------- Webster	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action---	Wetness--------	Wetness.
108, 108B--------- Wadena	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy------	Favorable.
135--------------- Coland	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness--------	Wetness.
136B-------------- Ankeny	Severe: seepage.	Severe: piping.	Severe: no water.	Deep to water	Soil blowing---	Favorable.
138B, 138C, 138C2- Clarion	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
138D2------------- Clarion	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
168B, 168C--------- Hayden	Moderate: seepage, slope.	Slight---------	Severe: no water.	Deep to water	Favorable------	Favorable.
168E, 168F--------- Hayden	Severe: slope.	Slight---------	Severe: no water.	Deep to water	Slope----------	Slope.
175, 175B, 175C--- Dickinson	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Soil blowing, too sandy.	Favorable.
201B*:						
Coland-----------	Moderate: seepage, slope.	Severe: wetness.	Moderate: slow refill:	Flooding, frost action, slope.	Wetness--------	Wetness.
Terril-----------	Moderate: seepage, slope.	Moderate: piping.	Severe: no water.	Deep to water	Favorable------	Favorable.
202, 203---------- Cylinder	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Favorable.
221--------------- Palms	Severe: seepage.	Severe: excess humus, ponding.	Severe: slow refill.	Ponding, subsides.	Ponding, soil blowing.	Wetness.
236B, 236C, 236C2- Lester	Moderate: seepage, slope.	Severe: thin layer.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
236D, 236D2, 236E, 236F------------- Lester	Severe: slope.	Severe: thin layer.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
253B-------------- Farrar	Severe: seepage.	Slight---------	Severe: no water.	Deep to water	Soil blowing---	Erodes easily.
259--------------- Biscay	Severe: seepage.	Severe: seepage, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Wetness.
274--------------- Rolfe	Moderate: seepage.	Severe: ponding.	Severe: slow refill.	Ponding, percs slowly, frost action.	Ponding--------	Wetness, percs slowly.
284, 284B--------- Flagler	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Favorable.
288--------------- Ottosen	Moderate: seepage.	Moderate: piping, wetness.	Severe: slow refill.	Frost action---	Wetness--------	Favorable.
356G*:						
Hayden-----------	Severe: slope.	Slight---------	Severe: no water.	Deep to water	Slope----------	Slope.
Storden----------	Severe: slope.	Moderate: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
386--------------- Cordova	Moderate: seepage.	Severe: wetness.	Severe: slow refill.	Frost action---	Wetness--------	Wetness.
388--------------- Kossuth	Moderate: seepage.	Severe: wetness.	Severe: slow refill.	Frost action---	Wetness--------	Wetness.
485--------------- Spillville	Moderate: seepage.	Moderate: piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable------	Favorable.

See footnote at end of table.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
506 Wacousta	Moderate: seepage.	Severe: piping, ponding.	Moderate: slow refill.	Ponding, frost action.	Not needed	Not needed.
507 Canisteo	Severe: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action	Wetness	Wetness.
536 Hanlon	Severe: seepage.	Severe: piping.	Severe: cutbanks cave.	Deep to water	Soil blowing	Favorable.
559 Talcot	Severe: seepage.	Severe: seepage, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Wetness.
638C2*:						
Clarion	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
Storden	Moderate: seepage, slope.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
638D2*:						
Clarion	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
Storden	Severe: slope.	Moderate: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
828B, 828C2 Zenor	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Favorable.
956*:						
Okoboji	Moderate: seepage.	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Erodes easily, ponding.	Wetness, erodes easily.
Harps	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action	Wetness	Wetness.
1178 Waukee Variant	Moderate: seepage.	Severe: piping.	Severe: no water.	Deep to water	Favorable	Favorable.
1314*:						
Hanlon	Severe: seepage.	Severe: piping,	Severe: cutbanks cave.	Deep to water	Soil blowing	Favorable.
Spillville	Moderate: seepage.	Moderate: piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable	Favorable.
1585*:						
Spillville	Moderate: seepage.	Moderate: piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable	Favorable.
Coland	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness	Wetness.
4000*. Urban land						
5010*, 5030*. Pits						
5040*, 5050*. Orthents						
5060*. Pits						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
6----------------- Okoboji	0-32	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	32-47	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	47-60	Silty clay loam	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
27B, 27C---------- Terril	0-32	Loam--------------	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	11-20
	32-60	Clay loam, loam	CL	A-6	0-5	100	100	85-95	65-85	25-40	11-20
34C--------------- Estherville	0-9	Sandy loam--------	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	9-16	Sandy loam, loam, coarse sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	16-60	Coarse sand, gravelly coarse sand, loamy coarse sand.	SP, SP-SM, SM	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
41B, 41C, 41D----- Sparta	0-16	Loamy fine sand	SM	A-2, A-4	0	85-100	85-100	50-95	15-50	---	NP
	16-39	Loamy fine sand, fine sand, sand.	SP-SM, SM	A-2, A-3, A-4	0	85-100	85-100	50-95	5-50	---	NP
	39-60	Sand, fine sand	SP-SM, SM, SP	A-2, A-3	0	85-100	85-100	50-95	2-30	---	NP
52B--------------- Bode	0-12	Clay loam---------	CL	A-6, A-7	0	95-100	95-100	75-90	55-80	35-50	15-25
	12-34	Clay loam---------	CL	A-6, A-7	0	95-100	90-100	75-90	55-80	35-50	15-25
	34-60	Loam--------------	CL, CL-ML	A-4, A-6	0-5	90-100	90-95	75-90	50-75	25-40	5-15
54---------------- Zook	0-16	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	45-65	20-35
	16-60	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	95-100	60-85	35-55
55---------------- Nicollet	0-17	Loam, clay loam	OL, ML, CL	A-6, A-7	0	95-100	95-100	85-98	55-85	35-50	10-25
	17-36	Clay loam, loam	CL	A-6, A-7	0-5	95-100	95-100	80-95	55-80	35-50	15-25
	36-60	Loam--------------	CL, ML	A-6, A-4	0-5	95-100	90-100	75-90	50-75	30-40	5-15
62C3, 62D, 62D3 62E, 62E3, 62F--- Storden	0-8	Loam--------------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	8-60	Loam--------------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
65F--------------- Lindley	0-11	Loam--------------	CL-ML, CL	A-4, A-6	0	95-100	90-100	85-95	50-65	15-30	5-15
	11-41	Clay loam, loam	CL	A-6, A-7	0	95-100	90-100	85-95	55-75	30-45	15-25
	41-60	Loam, clay loam	CL	A-6	0	95-100	90-100	85-95	50-70	30-40	15-25
90---------------- Okoboji	0-15	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-95	11-30
	15-33	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	33-40	Silty clay loam	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
	40-60	Stratified loam to silty clay loam.	CL, CH	A-7	0-5	95-100	90-100	90-100	75-90	40-55	20-30
95---------------- Harps	0-20	Loam, clay loam	CL, CH	A-6, A-7	0-5	100	95-100	80-90	65-80	30-55	15-35
	20-41	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-60	15-35
	41-60	Loam--------------	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
107--------------- Webster	0-17	Clay loam---------	CL, CH	A-7, A-6	0-5	100	95-100	85-95	70-90	35-60	15-30
	17-38	Clay loam, silty clay loam, loam.	CL	A-6, A-7	0-5	95-100	95-100	85-95	60-80	35-50	15-30
	38-60	Loam, sandy loam, clay loam.	CL	A-6	0-5	95-100	90-100	75-85	50-75	30-40	10-20

See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
108, 108B--------Wadena	0-12	Loam--------------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	12-25	Loam, sandy loam, sandy clay loam.	SM, ML, CL, SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	25-60	Sand and gravel	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
135---------------Coland	0-47	Clay loam---------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	47-60	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
136B-------------Ankeny	0-36	Fine sandy loam	SM, SC, SM-SC	A-4, A-2	0-5	95-100	95-100	75-90	30-50	<25	2-10
	36-48	Fine sandy loam	SM, SC, SM-SC	A-4, A-2	0-5	95-100	95-100	75-90	25-45	<25	2-10
	48-60	Loamy fine sand, fine sandy loam, fine sand.	SM, SC, SM-SC, SW-SM	A-4, A-2, A-3	0-5	95-100	95-100	50-75	5-40	<25	NP-10
138B, 138C, 138C2, 138D2----Clarion	0-13	Loam--------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	13-33	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	33-60	Loam, sandy loam	CL, CL-ML, SC, SM-SC	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
168B, 168C, 168E, 168F------------Hayden	0-8	Loam--------------	ML, CL-ML, CL	A-4	0	100	98-100	85-98	50-80	20-30	4-10
	8-53	Clay loam, loam	CL	A-7, A-6	0	95-100	90-98	80-95	55-75	30-50	15-26
	53-60	Loam, sandy loam, fine sandy loam.	CL, SC	A-6, A-4	0-5	95-100	90-98	75-90	35-70	20-35	8-15
175, 175B, 175C--Dickinson	0-17	Fine sandy loam	SM, SC, SM-SC	A-4, A-2	0	100	100	85-95	30-50	15-30	NP-10
	17-33	Fine sandy loam, sandy loam.	SM, SC, SM-SC	A-4	0	100	100	85-95	35-50	15-30	NP-10
	33-40	Loamy sand, loamy fine sand, fine sand.	SM, SP-SM, SM-SC	A-2, A-3	0	100	100	80-95	5-20	10-20	NP-5
	40-60	Sand, loamy fine sand, loamy sand.	SM, SP-SM	A-3, A-2	0	100	100	70-90	5-20	---	NP
201B*:											
Coland-----------	0-47	Clay loam---------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	47-60	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
Terril-----------	0-32	Loam--------------	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	10-20
	32-60	Clay loam, loam	CL	A-6	0-5	100	100	85-95	65-85	25-40	10-20
202---------------Cylinder	0-13	Loam--------------	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	13-27	Loam, clay loam, sandy clay loam.	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	27-60	Gravelly coarse sand, loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
203---------------Cylinder	0-19	Loam--------------	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	19-37	Loam, clay loam, sandy clay loam.	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	37-60	Gravelly coarse sand, loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
221---------------Palms	0-26	Sapric material	PT	---	---	---	---	---	---	---	---
	26-60	Clay loam, silty clay loam, fine sandy loam.	CL-ML, CL	A-4, A-6	0	85-100	80-100	70-95	50-90	25-40	5-20

See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
236B, 236C, 236C2, 236D, 236D2, 236E, 236F: Lester	0-11	Loam	ML, CL	A-6, A-4	0	95-100	90-100	80-95	50-70	30-40	5-15
	11-35	Clay loam, loam	CL	A-7, A-6	0-5	95-100	90-100	80-95	55-75	35-50	15-25
	35-60	Loam, clay loam	CL, CL-ML	A-6, A-4	0-5	95-100	90-100	75-90	50-70	20-40	5-20
253B: Farrar	0-14	Fine sandy loam	SC, SM-SC	A-2, A-4	0	100	100	85-95	25-45	<30	5-10
	14-20	Fine sandy loam	SC, SM-SC	A-2, A-4	0	100	100	85-95	25-45	<30	5-10
	20-60	Loam	CL	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	8-20
259: Biscay	0-16	Clay loam	CL, ML	A-7, A-6	0	95-100	95-100	70-90	50-75	35-50	10-25
	16-28	Loam, clay loam	CL, ML	A-6, A-7	0	95-100	90-100	70-90	50-75	30-50	10-20
	28-33	Gravelly loam, sandy loam.	SM, SM-SC, SC	A-4	0-5	95-100	70-95	50-80	35-50	15-30	2-10
	33-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, GP, GP-GM	A-1	0-5	45-95	35-95	20-45	2-10	---	NP
274: Rolfe	0-19	Loam	OL, CL, ML	A-6, A-4	0	100	95-100	90-100	80-95	30-40	5-15
	19-52	Clay, silty clay, clay loam, sandy clay loam.	CH	A-7	0	100	95-100	90-100	75-95	50-65	25-35
	52-60	Clay loam, loam	CL	A-7, A-6	0	95-100	90-100	80-90	55-75	30-45	10-20
284, 284B: Flagler	0-21	Sandy loam	SC, SM-SC	A-2, A-4	0	95-100	90-95	60-70	25-40	15-25	5-10
	21-32	Sandy loam	SC, SM-SC	A-2, A-4	0	95-100	90-95	50-70	25-40	15-25	5-10
	32-60	Loamy sand, gravelly sand.	SP-SM, SW, SP, SW-SM	A-1	0-5	70-90	70-85	20-40	3-12	---	NP
288: Ottosen	0-18	Clay loam	CL, CH	A-7	0	95-100	95-100	90-100	65-85	40-55	20-30
	18-35	Clay loam, silty clay loam.	CL, CH	A-7	0	95-100	95-100	90-100	65-85	40-55	20-30
	35-60	Loam	CL	A-4, A-6	0-5	90-100	90-100	80-95	60-75	25-40	8-20
356G*: Hayden	0-8	Loam	ML, CL-ML, CL	A-4	0	100	98-100	85-98	50-80	20-30	4-10
	8-32	Clay loam, loam	CL	A-7, A-6	0	95-100	90-98	80-95	55-75	30-50	15-26
	32-60	Loam, sandy loam, fine sandy loam.	CL, SC	A-6, A-4	0-5	95-100	90-98	75-90	35-70	20-35	8-15
Storden	0-17	Loam	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	17-60	Loam	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
386: Cordova	0-13	Clay loam	OL, ML, MH, OH	A-6, A-7	0	95-100	95-100	90-100	70-85	38-60	12-25
	13-41	Silty clay loam, clay loam.	CL	A-7	0	90-100	90-100	85-95	65-90	40-50	20-30
	41-60	Clay loam, loam	CL	A-6	0-5	90-100	90-100	80-95	55-70	30-40	12-20
388: Kossuth	0-22	Silty clay loam	CL, CH	A-7	0	95-100	95-100	80-85	75-85	40-60	20-30
	22-35	Silty clay loam, clay loam.	CL, CH	A-7	0	95-100	95-100	80-85	75-85	45-65	25-35
	35-60	Loam	CL	A-4, A-6	0-5	95-100	90-100	70-85	50-70	25-40	8-20
485: Spillville	0-60	Loam	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
506: Wacousta	0-13	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	40-65	20-40
	13-18	Silty clay loam, silt loam.	CH, CL	A-7	0	100	100	90-100	90-100	40-60	20-35
	18-60	Silt loam, silty clay loam.	CL, ML	A-6, A-4	0-5	95-100	95-100	85-100	80-90	30-40	5-15

See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
507--------------- Canisteo	0-23	Clay loam, silty clay loam.	OL, CL	A-7	0	98-100	95-100	85-98	60-90	40-50	15-20
	23-37	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	98-100	90-100	85-95	65-85	38-50	25-35
	37-43	Clay loam, loam, sandy loam.	CL, ML, SM, SC	A-6, A-4	0-5	90-100	80-95	60-90	40-80	30-40	5-15
	43-60	Clay loam, loam	CL	A-6	0-5	95-100	90-98	80-95	60-75	30-40	12-20
536--------------- Hanlon	0-39	Fine sandy loam	SM-SC, SC	A-4	0	100	100	75-80	35-50	25-35	5-10
	39-48	Sandy loam, fine sandy loam, loamy fine sand.	SM-SC, SC	A-4, A-2	0	100	100	75-80	25-40	15-25	5-10
	48-60	Loam, sandy loam, loamy sand.	SC, CL, SM-SC, CL-ML	A-4, A-6, A-2	0	100	100	80-90	20-60	15-35	5-15
559--------------- Talcot	0-19	Clay loam---------	CL	A-7	0	100	100	80-90	60-85	40-50	15-25
	19-35	Clay loam, silty clay loam, loam, sandy loam.	CL	A-7	0	95-100	85-100	70-90	60-85	40-50	15-25
	35-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM	A-1	0	65-90	50-85	20-50	2-10	---	NP
638C2*, 638D2*:											
Clarion----------	0-8	Loam--------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	8-24	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	24-60	Loam, sandy loam	CL, CL-ML, SC, SM-SC	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
Storden----------	0-8	Loam--------------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	8-60	Loam--------------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
828B, 828C2------- Zenor	0-11	Sandy loam--------	SM-SC, SC	A-2, A-4	0-5	85-95	80-95	60-70	25-40	15-25	5-10
	11-23	Sandy loam, loam	SM-SC, SC	A-2, A-4	0-5	85-95	80-95	50-70	25-40	15-25	5-10
	23-60	Gravelly loamy sand, gravelly sand, loamy sand.	SW, SP, SP-SM	A-1	0-5	85-95	80-90	20-40	3-12	<20	NP-5
956*:											
Okoboji----------	0-32	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	32-47	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	47-60	Silty clay loam	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
Harps------------	0-20	Clay loam---------	CL, CH	A-6, A-7	0-5	100	95-100	80-90	65-80	30-55	15-35
	20-41	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-60	15-35
	41-60	Loam--------------	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
1178-------------- Waukee Variant	0-22	Loam--------------	CL	A-6	0	100	90-100	70-90	50-75	30-40	10-20
	22-83	Loam--------------	CL, CL-ML	A-6, A-4	0	100	90-100	80-90	50-75	20-35	5-15
1314*:											
Hanlon-----------	0-39	Fine sandy loam	SM-SC, SC	A-4	0	100	100	75-80	35-50	25-35	5-10
	39-48	Sandy loam, fine sandy loam, loamy fine sand.	SM-SC, SC	A-4, A-2	0	100	100	75-80	25-40	15-25	5-10
	48-60	Loam, sandy loam, loamy sand.	SC, CL SM-SC, CL-ML	A-4, A-6, A-2	0	100	100	80-90	20-60	15-35	5-15
Spillville-------	0-60	Loam--------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	11-20

* See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
1585*:											
Spillville------	0-60	Loam--------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
Coland----------	0-47	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	47-60	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
4000*. Urban land											
5010*, 5030*. Pits											
5040*, 5050*. Orthents											
5060*. Pits											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH					Pct
6	0-32	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.6-7.8	High	0.37	5	4	9-18
Okoboji	32-47	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High	0.37			
	47-60	35-45	1.35-1.40	0.2-0.6	0.18-0.20	6.6-8.4	High	0.37			
27B, 27C	0-32	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	5	6	4-5
Terril	32-60	22-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low	0.32			
34C	0-9	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low	0.20	3	3	.5-2
Estherville	9-16	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low	0.20			
	16-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low	0.10			
41B, 41C, 41D	0-16	3-10	1.20-1.40	2.0-6.0	0.09-0.12	5.1-7.3	Low	0.17	5	2	.5-2
Sparta	16-39	1-8	1.40-1.60	6.0-20	0.05-0.11	5.1-6.5	Low	0.17			
	39-60	0-5	1.50-1.70	6.0-20	0.04-0.07	5.1-6.5	Low	0.17			
52B	0-12	32-36	1.40-1.50	0.6-2.0	0.17-0.19	6.1-7.3	Moderate	0.28	5	5	3-4
Bode	12-34	28-35	1.50-1.70	0.6-2.0	0.15-0.19	6.1-8.4	Moderate	0.28			
	34-60	22-27	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.28			
54	0-16	32-38	1.30-1.35	0.2-0.6	0.21-0.23	5.6-7.3	High	0.28	5	7	5-7
Zook	16-60	36-45	1.30-1.45	0.06-0.2	0.11-0.13	5.6-7.8	High	0.28			
55	0-17	24-35	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate	0.24	5	6	5-6
Nicollet	17-36	24-35	1.25-1.35	0.6-2.0	0.15-0.19	5.6-7.8	Moderate	0.32			
	36-60	22-28	1.35-1.45	0.6-2.0	0.14-0.19	7.4-7.8	Low	0.32			
62C3, 62D, 62D3, 62E, 62E3, 62F	0-8	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low	0.28	5	4L	<.5-2
Storden	8-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.37			
65F	0-11	18-27	1.20-1.40	0.6-2.0	0.16-0.18	4.5-7.3	Low	0.32	5	6	.5-1
Lindley	11-41	25-35	1.35-1.55	0.2-0.6	0.14-0.18	4.5-6.5	Moderate	0.32			
	41-60	18-32	1.40-1.60	0.2-0.6	0.12-0.16	6.1-7.8	Moderate	0.32			
90	0-15	20-26	1.20-1.25	0.6-2.0	0.24-0.26	6.6-7.8	High	0.37	5	4	9-18
Okoboji	15-33	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High	0.37			
	33-40	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High	0.37			
	40-60	20-30	1.40-1.50	0.6-2.0	0.18-0.20	7.4-8.4	Moderate	0.28			
95	0-20	25-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate	0.24	5	4L	4-5
Harps	20-41	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate	0.32			
	41-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.9-8.4	Moderate	0.32			
107	0-17	26-36	1.35-1.40	0.6-2.0	0.19-0.21	6.6-7.3	Moderate	0.24	5	6	6-7
Webster	17-38	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate	0.32			
	38-60	18-29	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate	0.32			
108, 108B	0-12	18-30	1.30-1.50	0.6-2.0	0.20-0.22	5.6-7.3	Low	0.24	4	5	3-4
Wadena	12-25	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low	0.32			
	25-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.1-8.4	Low	0.10			
135	0-47	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High	0.28	5	7	5-7
Coland	47-60	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High	0.28			
136B	0-36	10-18	1.50-1.55	2.0-6.0	0.16-0.18	6.1-7.3	Low	0.20	5	3	2-3
Ankeny	36-48	10-15	1.55-1.65	2.0-6.0	0.15-0.17	6.1-7.3	Low	0.20			
	48-60	2-10	1.65-1.75	6.0-20	0.12-0.14	6.1-7.3	Low	0.20			
138B, 138C	0-13	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low	0.28	5	6	3-4
Clarion	13-33	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low	0.37			
	33-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.37			

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH					Pct
138C2------------ Clarion	0-13	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6	2-3
	13-33	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37			
	33-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
138D2------------ Clarion	0-13	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6	1-2
	13-33	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37			
	33-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
168B, 168C, 168E, 168F------------ Hayden	0-8	10-25	1.40-1.60	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.32	5	6	1-3
	8-53	18-35	1.50-1.65	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.32			
	53-60	15-27	1.65-1.80	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.32			
175, 175B, 175C-- Dickinson	0-17	12-18	1.50-1.55	2.0-6.0	0.12-0.15	5.6-7.3	Low----------	0.20	4	3	1-2
	17-33	10-15	1.45-1.55	2.0-6.0	0.12-0.15	5.1-7.3	Low----------	0.20			
	33-40	5-10	1.55-1.65	6.0-20	0.08-0.10	5.1-7.3	Low----------	0.20			
	40-60	5-10	1.60-1.70	6.0-20	0.02-0.04	5.6-7.3	Low----------	0.15			
201B*:											
Coland----------	0-47	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7	5-7
	47-60	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28			
Terril----------	0-28	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	5	6	4-5
	28-60	22-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low----------	0.32			
202-------------- Cylinder	0-13	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate-----	0.24	4	6	4-5
	13-27	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate-----	0.32			
	27-60	2-12	1.60-1.70	>20	0.02-0.04	6.5-8.4	Low----------	0.10			
203-------------- Cylinder	0-19	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate-----	0.24	4	6	4-5
	19-37	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate-----	0.32			
	37-60	2-12	1.60-1.70	>20	0.02-0.04	6.5-8.4	Low----------	0.10			
221-------------- Palms	0-26	---	0.25-0.45	2.0-6.0	0.35-0.45	5.1-7.8	-------------	----	2	3	>20
	26-60	7-35	1.45-1.75	0.6-2.0	0.14-0.22	6.1-8.4	Low----------	----			
236B, 236C------- Lester	0-11	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low----------	0.28	5	6	2-4
	11-35	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.28			
	35-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-8.4	Low----------	0.37			
236C2------------ Lester	0-11	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low----------	0.28	5	6	1-2
	11-35	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.28			
	35-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-8.4	Low----------	0.37			
236D------------- Lester	0-11	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low----------	0.28	5	6	2-3
	11-35	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.28			
	35-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-8.4	Low----------	0.37			
236D2------------ Lester	0-11	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low----------	0.28	5	6	.5-2
	11-35	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.28			
	35-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-8.4	Low----------	0.37			
236E, 236F------- Lester	0-11	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low----------	0.28	5	6	1-2
	11-35	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.28			
	35-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-8.4	Low----------	0.37			
253B------------- Farrar	0-14	10-14	1.45-1.50	2.0-6.0	0.16-0.18	5.6-7.3	Low----------	0.20	5	3	1-2
	14-20	10-16	1.50-1.60	2.0-6.0	0.15-0.17	5.6-6.5	Low----------	0.20			
	20-60	18-24	1.60-1.80	0.6-2.0	0.17-0.19	6.1-8.4	Low----------	0.37			
259-------------- Biscay	0-16	18-30	1.20-1.30	0.6-2.0	0.20-0.22	6.1-7.8	Moderate-----	0.28	4	6	5-7
	16-28	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-7.8	Moderate-----	0.28			
	28-33	10-28	1.35-1.55	2.0-6.0	0.11-0.17	6.6-8.4	Low----------	0.28			
	33-60	1-6	1.55-1.65	6.0-20	0.02-0.04	6.6-8.4	Low----------	0.10			

See footnote at end of table.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH					Pct
274-------------- Rolfe	0-19	22-28	1.35-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Moderate-----	0.28	5	6	3-5
	19-52	38-45	1.40-1.50	0.06-0.2	0.11-0.13	5.6-7.3	High---------	0.28			
	52-60	24-35	1.50-1.60	0.2-2.0	0.14-0.16	6.1-8.4	Moderate-----	0.28			
284, 284B-------- Flagler	0-21	12-18	1.50-1.55	2.0-6.0	0.12-0.14	5.6-7.3	Low----------	0.20	4	3	1-2
	21-32	10-15	1.55-1.60	2.0-6.0	0.11-0.13	5.1-6.5	Low----------	0.20			
	32-60	2-8	1.60-1.75	>20	0.02-0.04	5.1-7.3	Low----------	0.20			
288-------------- Ottosen	0-18	32-40	1.35-1.45	0.2-0.6	0.19-0.22	5.6-7.3	Moderate-----	0.28	5	7	5-6
	18-35	30-40	1.45-1.55	0.2-0.6	0.17-0.19	6.1-8.4	Moderate-----	0.28			
	35-60	22-27	1.55-1.85	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.28			
356G*:											
Hayden----------	0-8	10-25	1.40-1.60	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.32	5	6	1-2
	8-42	18-35	1.50-1.65	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.32			
	42-60	15-27	1.65-1.80	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.32			
Storden---------	0-17	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	5	4L	1-2
	17-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
386-------------- Cordova	0-14	15-30	1.25-1.45	0.2-2.0	0.18-0.22	6.1-7.3	Moderate-----	0.28	5	6	5-7
	14-35	28-35	1.35-1.50	0.2-0.6	0.15-0.19	5.1-7.3	Moderate-----	0.28			
	35-60	18-30	1.45-1.70	0.6-2.0	0.14-0.16	7.4-8.4	Moderate-----	0.28			
388-------------- Kossuth	0-22	32-42	1.35-1.45	0.2-0.6	0.21-0.23	6.1-7.3	High---------	0.28	5	4	6-7
	22-35	35-42	1.45-1.55	0.2-0.6	0.18-0.20	6.1-7.8	High---------	0.28			
	35-60	23-27	1.55-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.28			
485-------------- Spillville	0-60	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
506-------------- Wacousta	0-13	27-35	1.20-1.25	0.6-2.0	0.21-0.23	6.1-7.8	High---------	0.28	5	7	8-10
	13-18	24-35	1.25-1.30	0.6-2.0	0.18-0.20	7.4-7.8	High---------	0.43			
	18-60	18-30	1.30-1.40	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.43			
507-------------- Canisteo	0-23	22-32	1.25-1.35	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.24	5	4L	4-8
	23-37	20-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32			
	37-43	10-35	1.30-1.50	0.6-6.0	0.12-0.18	7.4-8.4	Low----------	0.32			
	43-60	22-32	1.45-1.60	0.6-2.0	0.14-0.16	7.4-8.4	Low----------	0.32			
536-------------- Hanlon	0-39	12-18	1.50-1.70	2.0-6.0	0.16-0.18	6.1-7.3	Low----------	0.20	5	3	2-3
	39-48	5-10	1.70-1.75	2.0-6.0	0.11-0.13	5.6-7.3	Low----------	0.20			
	48-60	2-18	1.75-1.85	2.0-6.0	0.12-0.19	5.6-7.8	Low----------	0.20			
559-------------- Talcot	0-19	27-35	1.20-1.30	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.28	4	7	5-7
	19-35	25-35	1.25-1.35	0.6-2.0	0.17-0.20	7.4-8.4	Moderate-----	0.28			
	35-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15			
638C2*, 638D2*:											
Clarion---------	0-13	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6	1-3
	13-33	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37			
	33-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
Storden---------	0-9	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	5	4L	<.5
	9-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37			
828B, 828C2------ Zenor	0-11	14-18	1.50-1.55	2.0-6.0	0.14-0.16	5.6-7.3	Low----------	0.20	4	3	1-3
	11-23	14-18	1.55-1.60	2.0-6.0	0.13-0.15	6.1-8.4	Low----------	0.20			
	23-60	2-8	1.60-1.75	6.0-20	0.06-0.09	6.5-8.4	Low----------	0.10			
956*:											
Okoboji---------	0-20	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.6-7.8	High---------	0.37	5	4	9-18
	20-41	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High---------	0.37			
	41-60	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High---------	0.37			
	56-60	20-30	1.40-1.50	0.6-2.0	0.18-0.20	7.4-8.4	Moderate-----	0.28			

See footnote at end of table.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
Harps-----------	0-32	25-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate-----	0.24	5	4L	4-5
	32-47	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.32			
	47-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.32			
1178------------- Waukee Variant	0-22	18-25	1.40-1.45	0.6-2.0	0.20-0.22	5.1-6.5	Low----------	0.24	5	6	3-4
	22-83	18-22	1.40-1.50	0.6-2.0	0.15-0.19	5.6-6.5	Low----------	0.32			
1314*:											
Hanlon----------	0-39	12-18	1.50-1.70	2.0-6.0	0.16-0.18	6.6-7.3	Low----------	0.20	5	3	2-3
	39-48	5-10	1.70-1.75	2.0-6.0	0.11-0.13	5.6-7.3	Low----------	0.20			
	48-60	2-18	1.75-1.85	2.0-6.0	0.12-0.19	5.6-7.8	Low----------	0.20			
Spillville------	0-60	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
1585*:											
Spillville------	0-60	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
Coland----------	0-47	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	6	5-7
	47-60	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28			
4000*. Urban land											
5010*, 5030*. Pits											
5040*, 5050*. Orthents											
5060*. Pits											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "occasional," "brief," and "apparent" are explained in the text. The symbol > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
6*: Okoboji	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	High	High	Low.
27B, 27C: Terril	B	None	---	---	>6.0	---	---	Moderate	Moderate	Low.
34C: Estherville	B	None	---	---	>6.0	---	---	Low	Low	Low.
41B, 41C, 41D: Sparta	A	None	---	---	>6.0	---	---	Low	Low	Moderate.
52B: Bode	B	None	---	---	>6.0	---	---	Moderate	Moderate	Low.
54: Zook	C/D	Frequent	Brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-May	High	High	Moderate.
55: Nicollet	B	None	---	---	2.5-5.0	Apparent	Nov-May	High	High	Low.
62C3, 62D, 62D3, 62E, 62E3, 62F: Storden	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
65F: Lindley	C	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
90*: Okoboji	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	High	High	Low.
95: Harps	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jun	High	High	Low.
107: Webster	B/D	None	---	---	1.0-2.0	Apparent	Nov-Jul	High	High	Low.
108, 108B: Wadena	B	None	---	---	>6.0	---	---	Low	Low	Low.
135: Coland	B/D	Frequent	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
136B: Ankeny	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
138B, 138C, 138C2, 138D2: Clarion	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
168B, 168C, 168E, 168F: Hayden	B	None	---	---	>6.0	---	---	Moderate	Low	Moderate.
175, 175B, 175C: Dickinson	B	None	---	---	>6.0	---	---	Moderate	Low	Moderate.
201B**:										
Coland	B/D	Frequent	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
Terril	B	None	---	---	>6.0	---	---	Moderate	Moderate	Low.
202, 203: Cylinder	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	High	Moderate	Low.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
221*: Palms	A/D	None	---	---	+1-1.0	Apparent	Nov-May	High	High	Moderate.
236B, 236C, 236C2, 236D, 236D2, 236E, 236F: Lester	B	None	---	---	>6.0	---	---	Moderate	Low	Moderate.
253B: Farrar	B	None	---	---	>6.0	---	---	Moderate	Moderate	Low.
259: Biscay	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jun	High	Moderate	Low.
274*: Rolfe	C	None	---	---	+1-1.0	Apparent	Nov-Jul	High	High	Moderate.
284, 284B: Flagler	B	None	---	---	>6.0	---	---	Low	Moderate	Low.
288: Ottosen	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	High	High	Low.
356G**:										
Hayden	B	None	---	---	>6.0	---	---	Moderate	Low	Moderate.
Storden	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
386: Cordova	C/D	None	---	---	1.0-3.0	Apparent	Nov-May	High	High	Low.
388: Kossuth	B/D	None	---	---	1.0-2.0	Apparent	Nov-Jul	High	High	Low.
485: Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.
506*: Wacousta	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	High	High	Low.
507: Canisteo	C/D	None	---	---	1.0-3.0	Apparent	Oct-Jul	High	High	Low.
536: Hanlon	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jun	Moderate	Moderate	Low.
559: Talcot	B/D	None	---	---	1.0-2.5	Apparent	Nov-Jul	High	High	Low.
638C2**, 638D2**:										
Clarion	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
Storden	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
828B, 828C2: Zenor	B	None	---	---	>6.0	---	---	Low	Low	Low.
956**:										
Okoboji*	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	High	High	Low.
Harps	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jun	High	High	Low.
1178: Waukee Variant	B	None	---	---	>6.0	---	---	Low	Low	Moderate.
1314**:										
Hanlon	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jun	Moderate	Moderate	Low.
Spillville	B	Frequent	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.

See footnotes at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
1585**:										
Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.
Coland	B/D	Frequent	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
4000**. Urban land										
5010**, 5030**. Pits										
5040**, 5050**. Orthents										
5060**. Pits										

* In the "High water table--Depth" column, a plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

** See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Ankeny	Coarse-loamy, mixed, mesic Cumulic Hapludolls
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Bode	Fine-loamy, mixed, mesic Typic Hapludolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Cordova	Fine-loamy, mixed, mesic Typic Argiaquolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Dickinson	Coarse-loamy, mixed, mesic Typic Hapludolls
Estherville	Sandy, mixed, mesic Typic Hapludolls
Farrar	Fine-loamy, mixed, mesic Typic Hapludolls
Flagler	Coarse-loamy, mixed, mesic Typic Hapludolls
Hanlon	Coarse-loamy, mixed, mesic Cumulic Hapludolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Hayden	Fine-loamy, mixed, mesic Typic Hapludalfs
Kossuth	Fine-loamy, mixed, mesic Typic Haplaquolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
Lindley	Fine-loamy, mixed, mesic Typic Hapludalfs
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Orthents, loamy	Loamy, mixed mesic Typic Udorthents
Orthents, sandy	Sandy, mixed mesic Typic Udorthents
Ottosen	Fine-loamy, mixed, mesic Aquic Hapludolls
Palms	Loamy, mixed, euic, mesic Terric Medisaprists
*Rolfe	Fine, montmorillonitic, mesic Typic Argialbolls
Sparta	Sandy, mixed, mesic Entic Hapludolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls
Wacousta	Fine-silty, mixed, mesic Typic Haplaquolls
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Waukee Variant	Fine-loamy, mixed, mesic Typic Hapludolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls
Zenor	Coarse-loamy, mixed, mesic Typic Hapludolls
Zook	Fine, montmorillonitic, mesic Cumulic Haplaquolls

* The soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series.

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